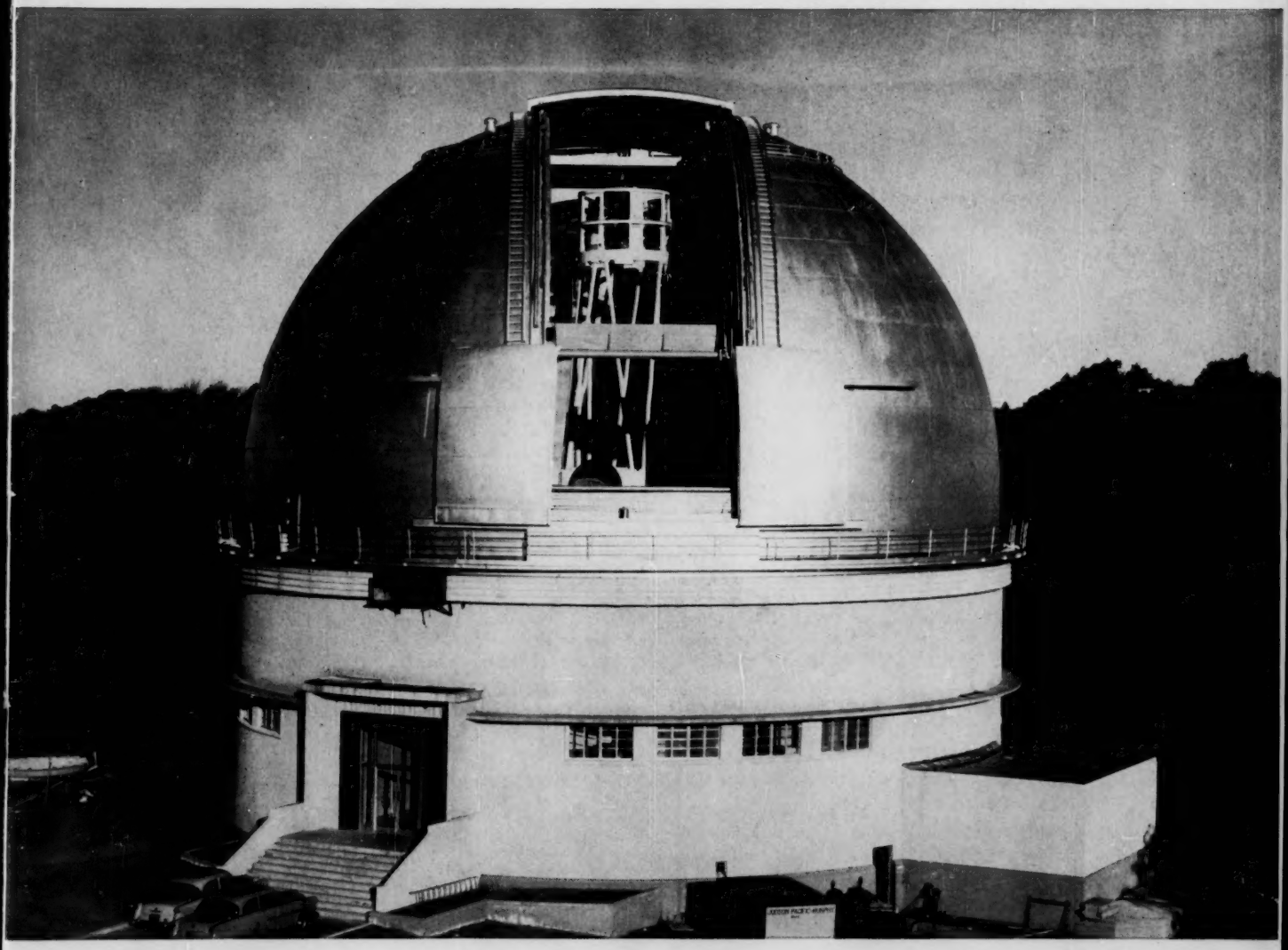
Sky and TELESCOPE



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Vol. XIV, No. 7

MAY, 1955

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The Duplicity of Nova Herculis

How Long Totality?

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Stars for May

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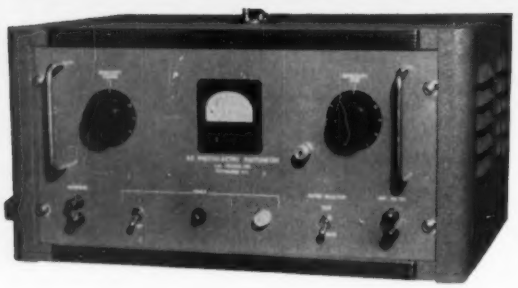

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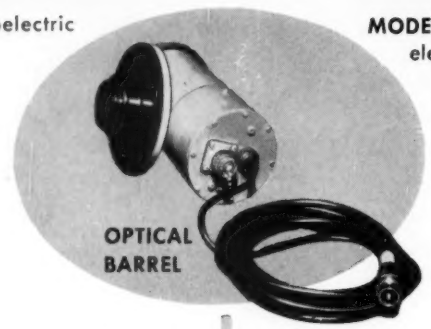

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Sky and TELESCOPE

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More Eclipse Notes

THE JUNE 20, 1955, total eclipse of the sun provides one of the infrequent opportunities for accurate measurement of the brightness of the inner corona. Even in the best existing coronagraphs the innermost part of the corona is drowned out by scattered sunlight, and its detailed changes in the course of the solar cycle can be studied only at eclipses.

The inner corona is the main concern of a Harvard Observatory expedition to Ceylon, under the leadership of Dr. W. M. Sinton. The tentative site of this party is Sigiriya, close to the central line of the eclipse in the middle of the island, where good weather can be expected in the lee of mountain ranges that ward off the southwest monsoon.

Twin telescopes with matched lenses are to be mounted on the same fork, each one alternately to observe the equatorial regions of the corona while the other observes the polar regions. Both instruments are fitted with diaphragms, letting through light from the corona at 0.05 to 0.35 solar radii, counted outwards from the sun's edge. The coronal brightness will be measured at each telescope with a phototransistor, whose meter deflections will be photographed as well as read visually.

Observations are to be made successively through five light filters, each having a pass band 200 angstroms wide, centered at selected wave lengths from 3540 angstroms in the ultraviolet to 15,000 in the infrared. A set of measures in all five colors will take one minute. Measurements through the violet filter, near wave length 3850 angstroms, may clarify the much-discussed question of whether there is any trace of atomic absorption lines in this part of the spectrum of the inner corona. In general, the Fraunhofer lines are invisible in the inner corona, because of scattering by fast-moving electrons, but the strongest lines may be detectable.

Along with several other university groups, Harvard is carrying out the eclipse observations under a research study sponsored by Trans World Airlines, Inc. The observers will fly to Ceylon via TWA in June.

Three Japanese organizations are sending a joint expedition to Polonnaruwa, Ceylon: Tokyo Observatory, the astrophysical department of Kyoto University, and the astronomy department of Tohoku University.

Led by Prof. M. Huruhata, the six-man Tokyo team will make photoelectric measurements of the brightness of the outer corona and the zodiacal light. From such observations the distribution of interplanetary particles in the vicinity

(Continued on page 292)

COUNTING PHOTONS — One by One

WILLIAM A. BAUM, *Mount Wilson and Palomar Observatories*

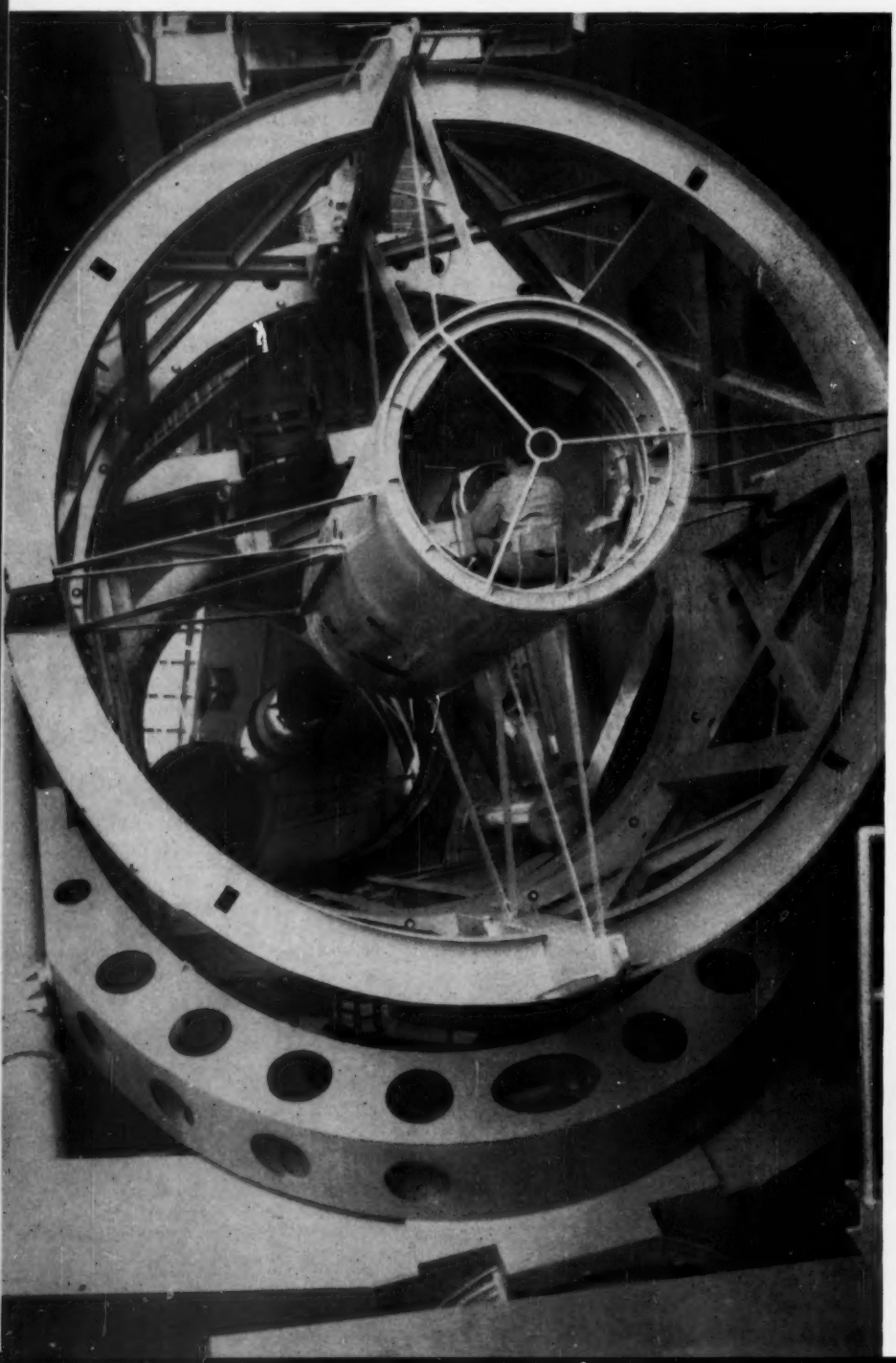
ONE of the most challenging and exciting problems in modern astronomy is determining the distances of remote galaxies and their distribution in space out to the limits of the observable universe. These are basic data needed for eventually deciding whether the universe is finite or infinite and for determining its fundamental physical properties.

Observationally, the key to such cosmological data is the accurate photometry of faint objects. The intercomparisons of remote galaxies (in luminosity, angular spread, and spectral-energy distribution) depend upon it; and the establishment of a cosmic yardstick by means of recognizable kinds of objects within nearby galaxies also depends upon it.

Until recent years our photometric results, and hence our concept of the universe, have rested entirely upon photographically derived magnitude scales. Photoelectric data now reveal that these photographic scales were sometimes off as much as a whole magnitude. At the moment, we don't really know how far out in the universe we are reaching, we don't know whether the red shift increases linearly with distance, and we haven't the foggiest notion whether the universe is finite or infinite.

Prospects for the future, however, are exceedingly encouraging. Recent photoelectric developments (such as those discussed by Dr. Otto Struve in the March and April issues) have opened up opportunities to tackle these problems anew by unassailable procedures and with sound hopes of finding real answers. For one thing, the response of a photoemissive cathode is inherently linear, thus by-passing the previous headaches of scale calibration.

By 1950, photoelectric photometry had been carried down to the 19th magnitude, where the conventional direct-current (d.c.) method of registration imposed a practical limit. Then, by the adoption of charge-integrating techniques, such as those described in this article, it has been possible within the past two years to make the final jump from 19th down to 23rd magnitude. This puts astronomical photometry on a firm basis over the entire range of observable objects. If an object can be detected photographically, it can



Looking down into the tube of the 200-inch Hale telescope, we see the observer in the prime-focus cage, where he rides with the instrument as it follows the object under observation across the sky. When the telescope points vertically, the observer is nearly 70 feet above the floor of the dome. It is at the prime focus that the photoelectric work described in this article is carried on. The 200-inch mirror itself is seen left of center, with the large, dark reflection of the prime-focus cage. All illustrations in this article are from Mount Wilson and Palomar Observatories.

now also be measured photoelectrically; it is even possible to detect things photoelectrically that are too faint to be photographed.

Let's see how a photoelectric photometer is used for measuring faint objects. Suppose that you want to photometer some faint stars in a field such as that shown in Fig. 1. If you look through an eyepiece at the prime focus of the 200-inch telescope, you will be able to see the 17th-magnitude star quite easily. You will also have no difficulty picking out the 18th-magnitude star, but you'll have a hard time placing it on crosshairs or centering it in a diaphragm. The 19th-magnitude star requires averted vision, while 20th, 21st, and 22nd are not visible at all. Consequently, stars of the 17th magnitude and brighter can be found visually, while fainter ones must be located by offsetting the instrument from brighter stars using co-ordinate offsets determined from a photograph such as this one.

Specifically, suppose that you want to photometer the faint star (about 21st magnitude) whose x and y position relative to the brighter star is indicated. First you operate the controls of the telescope to bring the image of the bright reference star into the center of a small focal-plane diaphragm; this is actually a pinhole in a thin metal plate. Then you find another bright star near the edge of the telescope's field and center the crosshairs of a guiding eyepiece on it. While manipulating the telescope to keep this guide star on the crosshairs, you now offset the pinhole in x and y from the reference star to the location of the invisible faint star. Then, placing the photoelectric photometer head behind the pinhole, you measure the light coming through it.

The photometer reading includes not only the light of the faint star but contributions due to the night sky glow and the dark emission of the photocathode. Therefore, while continuing to keep the guide star on the crosshairs, you shift the pinhole to a vacant patch of sky neighboring the faint star and take a second reading. This tells you how much sky light and dark emission to subtract from the first reading in order to obtain a true measurement of the star alone. For stars fainter than 19th magnitude, the contribution of the star itself is generally much less than that of the sky. Although this means that the readings must be of appreciable duration to attain accuracy, the guide star enables you to correct for minor errors in the telescope drive and thereby keep the pinhole diaphragm where it belongs while all this is going on. In Fig. 1, the small circles centered on the faint star and on a vacant sky patch next to it represent a diaphragm four seconds of arc in diameter.

To determine the color of a star, the process just described is simply carried out with two or more color filters in succession.

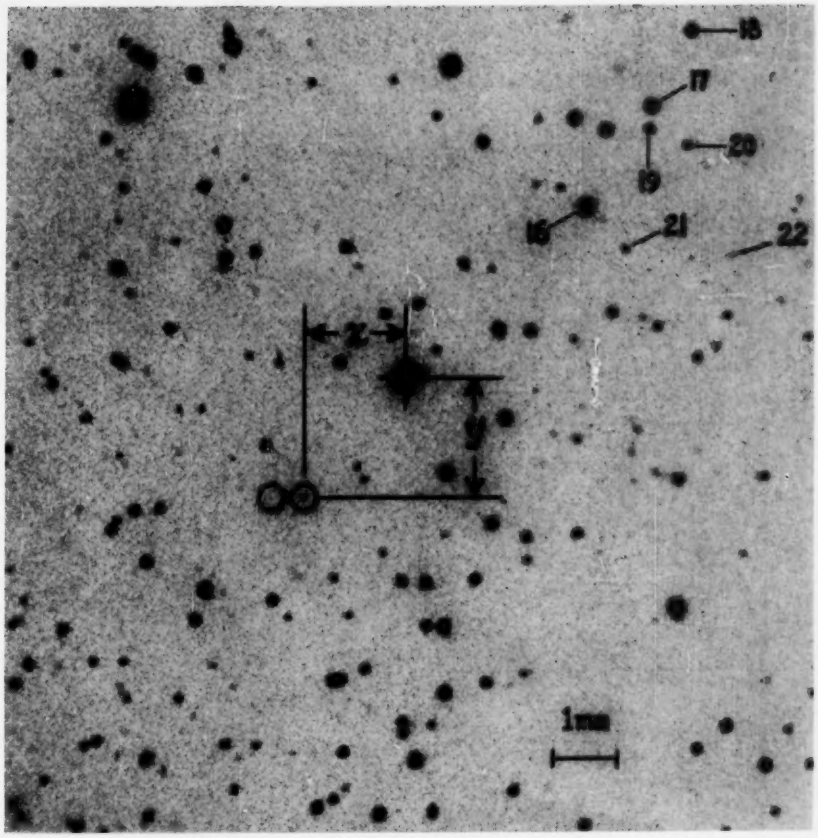


Fig. 1. Co-ordinate offsets must be used when making photoelectric measurements of stars too faint to be seen through the telescope. The approximate magnitudes of some stars are marked on this 200-inch photograph. Stars fainter than 17th magnitude are generally located by offsetting.

The electrical output signal from the phototube can be handled in various ways. Most commonly it is fed into a d.c. feedback amplifier and thence to a strip-chart pen recorder. Or it can be chopped and amplified by a.c. circuitry. Another way is to feed the output to a condenser and measure the charge accumulated during timed intervals. And still another way (if the tube is a photomultiplier) is to count the individual photon pulses during timed intervals. There'll be more to say about this photon-counting method later.

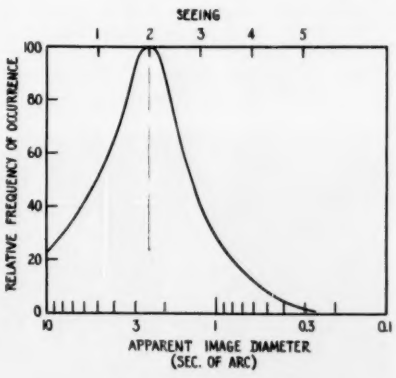


Fig. 2. The relative frequency with which different qualities of seeing occur at Mount Palomar, for the Hale telescope.

Now that we've considered how an astronomical photoelectric photometer is used, suppose that our goal is to reach the faintest level we can with as high an accuracy as possible. Two natural phenomena limit this effort: seeing and the night air glow.

The image of a star at the focus of a large telescope is a fuzzy blob whose size is determined almost solely by the quality of the seeing, that is, by the amount of turbulence in the earth's atmosphere through which the starlight passes. Fig. 2 shows how often different qualities of seeing were encountered on photoelectric runs at Palomar during 1951 and 1952. The smoothed curve is based on visual estimates using 10th-magnitude stars. Apparent image diameters, including the wanderings of the image, are plotted in seconds of arc at the bottom. Numbers at the top are merely arbitrary designations in local use. You can see from the curve that images are most frequently

smeared over two or three seconds of arc, and that images much smaller than one second of arc are relatively rare. One second of arc corresponds to about 0.1 millimeter at the 200-inch prime focus.

As Dr. Struve explained in March, the night air glow imposes a more-or-less uniform background against which these smeared-out images must be measured. Although its surface brightness varies a bit from night to night, the air glow averages 22nd magnitude per square second of arc. It actually sheds more light on the earth than all the stars combined, and is never absent.

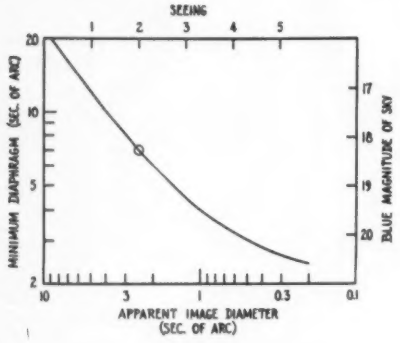


Fig. 3. Minimum pinhole diameters that can be used under various seeing conditions.

It turns out that seeing and night air glow limit the faintness attainable in photoelectric photometry much more than instrument performance does. This is because the smallest diaphragm that can safely enclose a smeared stellar image still admits appreciable night-sky radiation to the photometer. In Fig. 3, minimum safe diaphragm diameters permitted by the seeing are plotted against image diameters. Diaphragm sizes smaller than those indicated have been found to introduce erratic errors and to be uncomfortably sensitive to centering. The scale at the right indicates the equivalent magnitude of the night-sky radiation admitted by the corresponding diaphragm size labeled at the left. For average seeing (indicated by the small circle), you need to use a diaphragm equivalent to seven seconds of arc in the sky and tolerate a sky background effect of about 18th magnitude. When one-second images occur, you can close the diaphragm down to four seconds and thereby reduce the contribution of the sky background to fainter than 19th magnitude. Since it's important to include as little sky background as possible, you always make the diaphragm as small as the seeing allows, and you always save the best seeing for tackling the faintest objects.

The same size of diaphragm was used on the two stars whose tracings are shown in Fig. 4, but the faint one (at the left) was recorded with much higher amplification. During sections of the tracing marked *1*, the shutter was closed; at *2* the shutter was open and the star image was centered in the diaphragm; for *3* the diaphragm was shifted to a vacant sky patch neighboring the star. The contribution of the star itself is the difference between levels *2* and *3*. In the case of the bright star, the light from the star dwarfed the contribution of the sky background. But in the case of the faint star, you can see that most of the light came from the sky and that the star added very little, so little in fact that fluctuations in the tracing introduce a very large uncertainty into the measurement.

Nor is there much that can be done directly to improve the accuracy here. It has been found in practice that neither suppressing these fluctuations electronically nor extending the duration of the tracing will add much information, because variations in the brightness of the night sky tend to defeat any effort in that direction. In principle, one might repeat the measurement a great many times to accumulate information, that is, continue to move back and forth between star and sky, but the procedure would be clumsy at best. In short, 21st-magnitude stars, such as this one, are too faint to be measured with sufficient accuracy by a conventional d.c. system of this type. The practical limit is around 19th magnitude.

Fluctuations in the tracings arise from three causes: amplitude modulation caused by atmospheric turbulence, noise introduced by the instrument, and photon shot noise. The third is the one that really counts. It is of importance because we are dealing with relatively few photons per second and their rate of arrival is purely random. It can be shown that the fluctuations in the tracing of the faint star in Fig. 4 have just the amplitude to be expected from the known photon flux and photocathode efficiency.

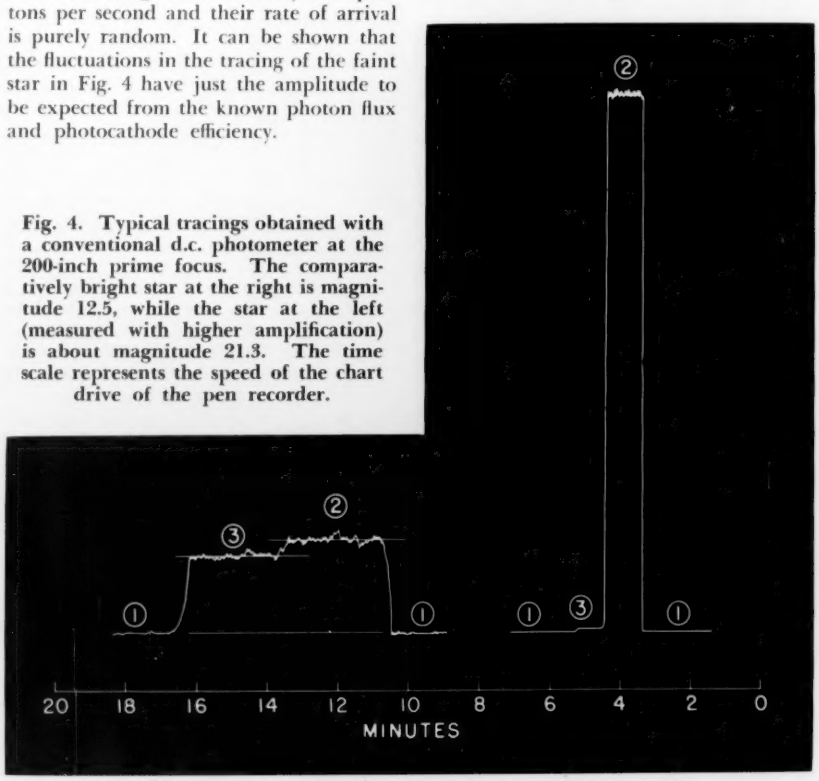


Fig. 4. Typical tracings obtained with a conventional d.c. photometer at the 200-inch prime focus. The comparatively bright star at the right is magnitude 12.5, while the star at the left (measured with higher amplification) is about magnitude 21.3. The time scale represents the speed of the chart drive of the pen recorder.

Since the random arrival of photons is the dominating factor in determining the accuracy of measurement, we should in principle be able to attain any accuracy we please simply by accumulating information long enough. In other words, the limitation of conventional d.c. apparatus (or any other current-measuring technique) is imposed by the fact that it is a rate-of-charge method of registration. We must adopt a charge-integrating system instead. This is only a practical choice, because there is very little theoretical difference between the two basic methods so long as the observation interval is the same.

However, there are at least two ways by which to accumulate information over long exposure times using a charge-integrating system. Either we can accumulate charge on a condenser during timed intervals, or we can count individual photons during timed intervals. The condenser method has been developed by H. L. Johnson at Lowell Observatory, while the photon-counting method is the one now in use at Palomar.

Let's first consider how many photons we should need to count (or somehow utilize) in order to attain a prescribed accuracy. The random statistical variation in the rate of arrival of photons sets a theoretical limit on the accuracy. If other sources of error can be neglected, the uncertainty of a photon count should be proportional to the square root of the count. Let N represent the number of background counts (sky plus dark) per unit time, and let n be the (small) number of star counts per unit time super-

posed upon this background. It follows from the laws of statistics that the exposure time t required to determine n alone (that is, to measure a faint object), with a probable error ε, is approximately $t = N/\varepsilon^2 n^2$.

What does this expression tell us? If the sky background N becomes brighter, for example due to moonlight, the exposure time must be increased in direct proportion. If one star is fainter than another by a factor 2 (which corresponds to about three quarters of a magnitude), the time should be multiplied by 4. And it must also be multiplied by 4 if you want to double the accuracy. Keeping this relationship in mind, approximately how many photon counts per second are registered by the Palomar photon-counting photometer at various magnitude levels?

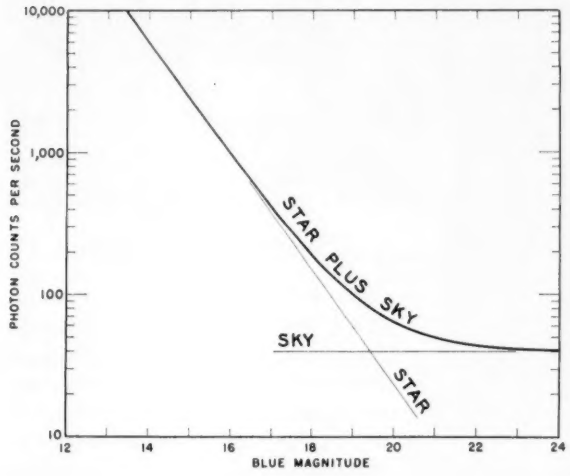


Fig. 5. A graph of the approximate counting rate at various magnitudes for the photon-counting photometer now in use at Palomar shows that, when very faint stars are being measured, most of the total count is contributed by the sky background. These rates are for a diaphragm four seconds of arc in diameter.

Fig. 5 is a logarithmic plot of the counting rate as a function of magnitude observed at the zenith on Palomar Mountain, through a band in the blue 1,000 angstroms wide. The relationship for the star contribution alone is a straight line; it passes through 10 counts per second at 21st magnitude and would be down to one count per second at magnitude 23.5. Through a diaphragm for four seconds of arc, which is a pinhole 0.4 millimeter in diameter, the sky background normally amounts to about 40 counts per second, as indicated. That, of course, is for a dark night without moonlight. Dark emission of the photomultiplier in present use adds only a few counts per second; we can imagine it to be included in the sky background. The sum of star plus sky is represented by the curve.

Now let's take a particular example. Suppose that you want to photometer a 23.5-magnitude star at Palomar with an accuracy of 10 per cent. That's asking quite a lot, because such a star can barely be detected, let alone measured, by any photographic means. Since the sky background gives 40 counts per second through a four-second diaphragm, the one count per second from the 23.5-magnitude star would amount to only 1/40 the total signal. Putting these values of n and N into the formula and taking $\varepsilon = 0.1$, you find that the required exposure time is 4,000 seconds, or slightly more than an hour. This means one hour with the diaphragm centered on the star and another hour with it placed on a vacant sky patch, making a total of two hours. Of course, since the night sky brightness tends to vary somewhat, you must break up these exposures into a series of short intervals devoted alternately to the two diaphragm positions.

Actually, this two-hour series will also be doubled or trebled, because a star must almost always be measured in at least two or three colors for the result to be astronomically useful. The total now stands at four to six hours, and it should be padded still further to allow for setting-up time, for shuttling the diaphragm back and forth, for calibration and extinction measurements, for a coffee break, and so on. In general, you would not be able to measure more than one such star in a night. Since the seeing and transparency are good enough for observations of this sort about one night in seven, your average output would be only one 23.5-magnitude star per week of observing. From an administrative or operational point of view, this makes 10 per cent accuracy at magnitude 23.5 rather expensive—say, several thousand dollars per star! Nevertheless, such measures are of key importance.

Next month we shall look at the actual photon-counting photometer by which such measurements have been made at Palomar, and describe some of the results obtained.

(To be continued)

A 60-foot Radio Telescope for Harvard Observatory

FOUR years after the first detection of 21-cm. radio emission from interstellar neutral hydrogen, at Harvard University by H. I. Ewen and E. M. Purcell, Harvard has been granted funds by the National Science Foundation to construct and operate a large radio telescope—a parabolic reflector 60 feet in diameter. Its construction will take about a year.

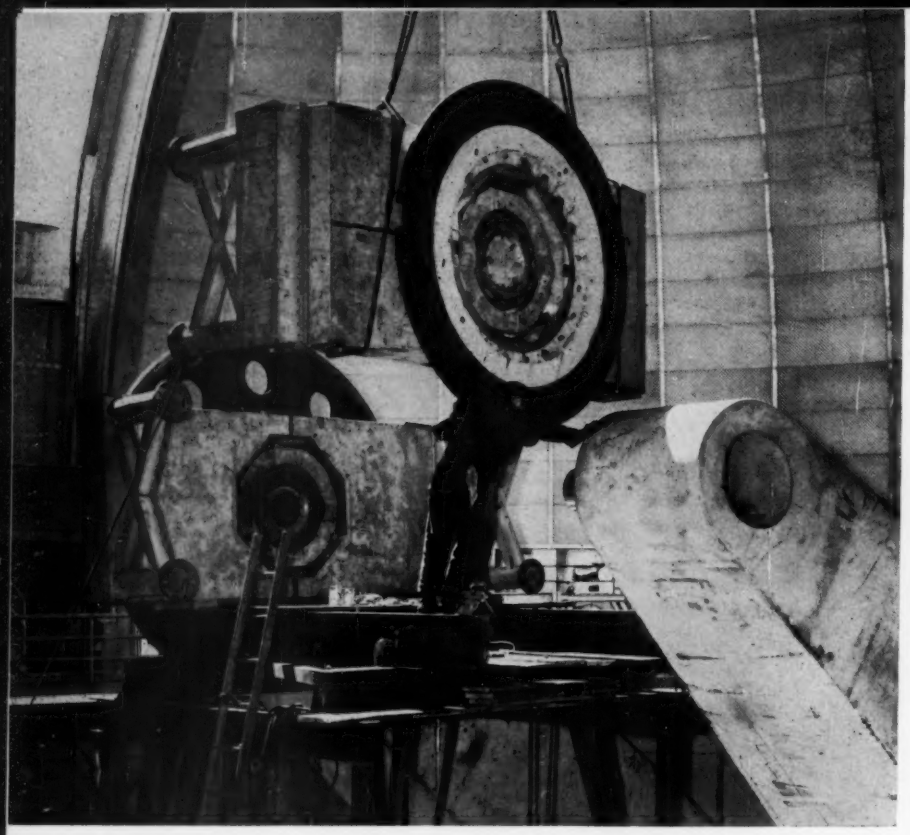
The radio astronomy project at Harvard is directed jointly by Profs. Bart J. Bok and R. W. Willson, and Dr. Ewen. With graduate students, they have made considerable progress in the study of neutral hydrogen clouds, using a 25-foot radio telescope built with an NSF grant several years ago. The two antennas will be about 300 yards apart on the grounds of the Agassiz station of Harvard Observatory, near the town of Harvard, Mass.

The new instrument will supplement rather than replace the smaller one. It will have approximately three times the resolving power of the 25-foot antenna, allowing positions of radio sources to be determined within about half a degree.

One important task for the 60-foot will be the examination of Milky Way areas where small, dense, dark clouds, rich in neutral hydrogen, abound. Many astronomers believe that stars may be forming in these globules. The new studies may therefore help explain the origin of stars.

The National Science Foundation grant is part of a larger program to support radio astronomy in the United States. Of the amount awarded, Harvard has designated $95,000 for construction of the radio telescope, and $37,000 for operating expenses.

A three-foot-high scale model of the new radio telescope to be erected at the Agassiz station, 30 miles west of Boston. Photograph, courtesy D. S. Kennedy and Co.



July 7, 1954. The center section of the telescope tube will be square. Here its east panel is already in place on the stub axle, with the declination gear attached to its far side. The west panel, with the pulley that will carry the declination preload cable, is being lowered into place.

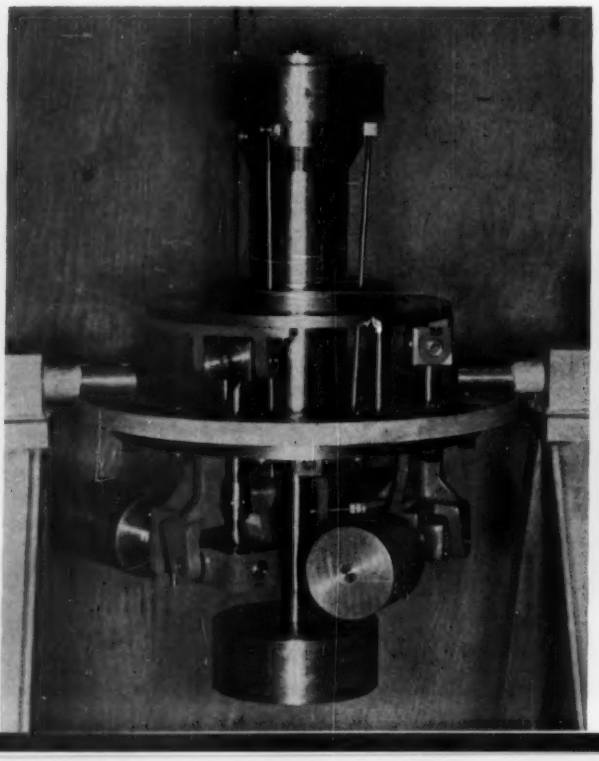
Lick Observatory

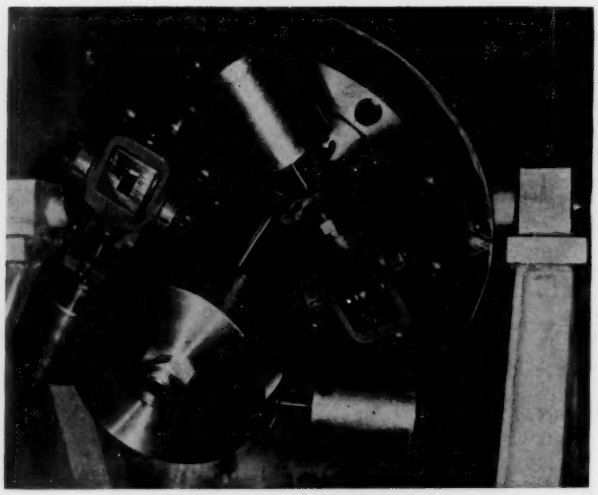
120-INCH ALBUM

J. F. CHAPPELL
AND W. W. BAUSTIAN
Lick Observatory
University of California

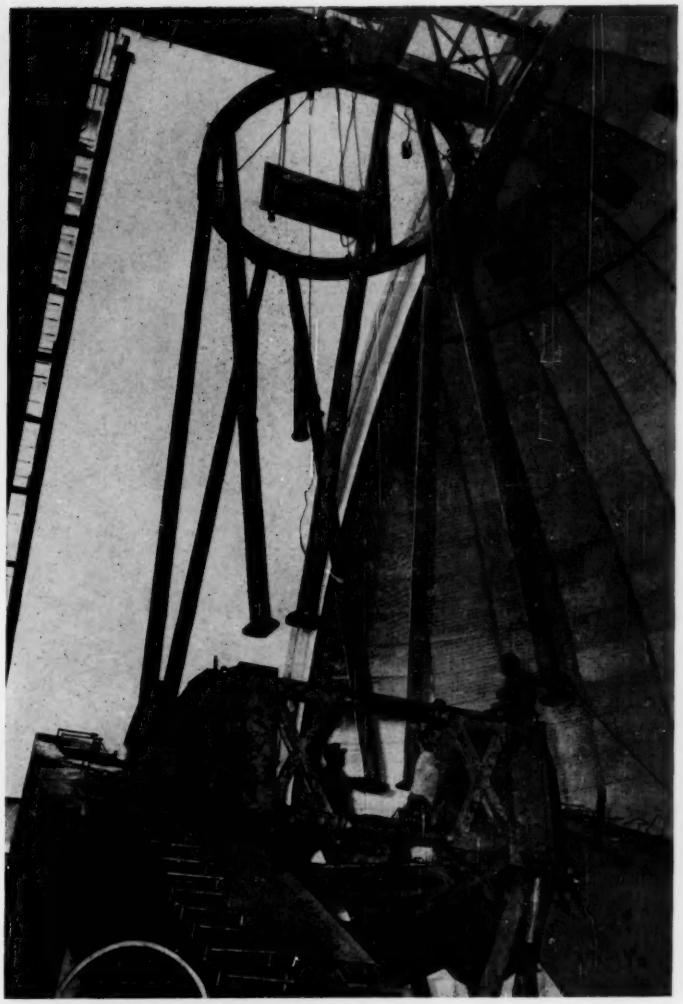
This is the third and last installment of a picture story on the construction of the world's second largest telescope, the 120-inch reflector at Lick Observatory. A short article on the history of the project and plans for observing programs using the instrument appeared in March.

Below: Associated with the picture of June 10, 1954 (page 235, April issue), are these two views of one of the 600-pound mirror support systems, here on the assembly jig. At the left, the system is vertical, in the position it will have when the mirror is horizontal. Uppermost is the bearing assembly of the radial support, which fits into a circular pocket of the mirror back. This radial bearing is counterweighted by the single central weight at the bottom of the picture, attached to a lever running through the center of the hollow support column. The retractable slender rods will support the radial bearing cage during installation. Next uppermost is the intermediate flange that will bear against the back of the ribs forming the circular mirror pocket. This flange is supported by three push rods, gimbal mounted at each end and counterweighted by the cylindrical weights and lever systems seen best in the right-hand picture. The total friction for the entire system is less than 0.2 per cent. Each unit will be attached to the under side of the upper plate of the mirror cell by 12 half-inch mounting bolts, seen here holding the support unit to the jig flange. Any of the 18 complete units can be installed or removed from the mirror cell without disturbing the mirror; the assembly for the central hole will contain a back-support unit only, so Cassegrainian light can pass through it unhindered.

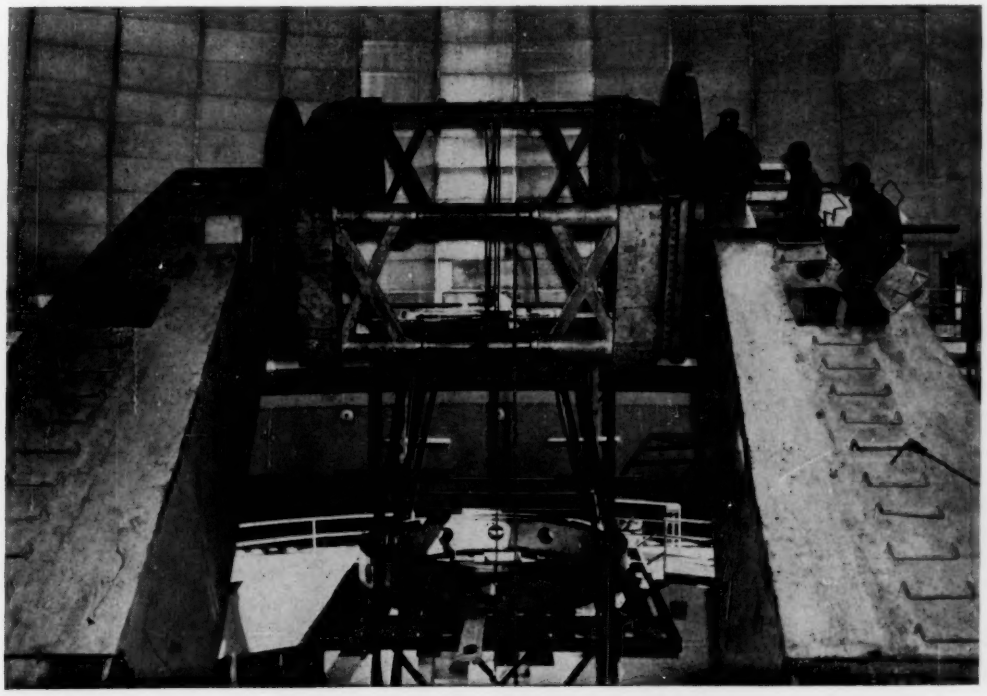




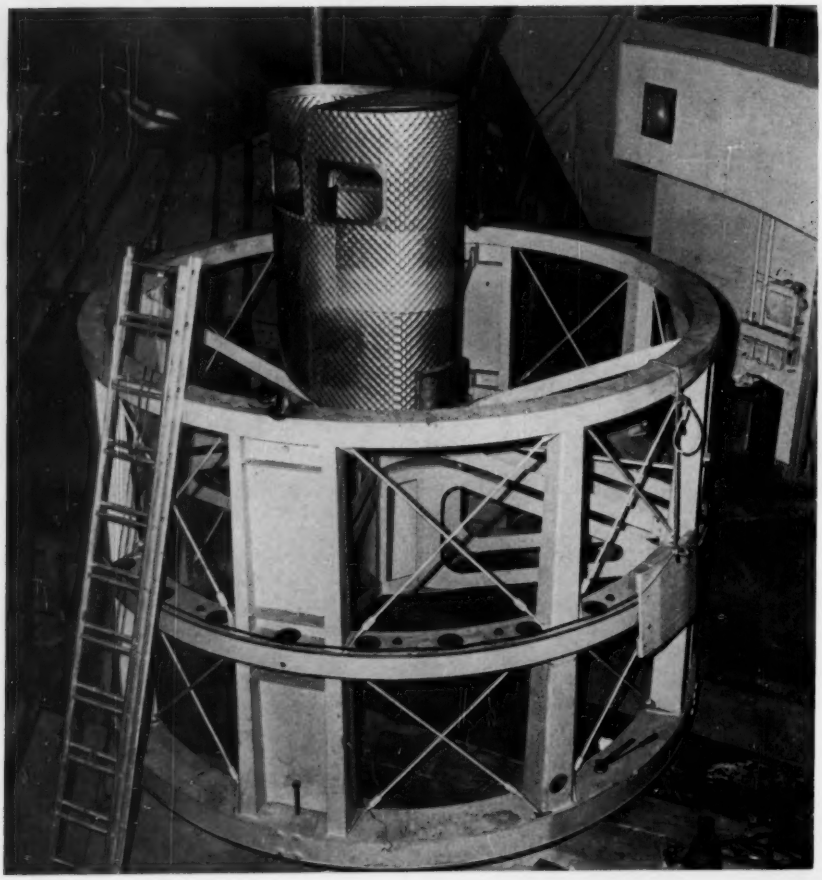
Above: July 7, 1954. A view of the gimbal joint between the declination axle and the western side of the center section of the telescope tube. Provision is included for adjusting the tube position with respect to the declination axis. The declination bearings consist of a pair of ball-bearing units, of the preloaded angular-contact type.



Below: July 9, 1954. The center section of the telescope tube is in place, held with temporary spacers. The lower ring girder (12½ feet in outside diameter) at the mirror end of the tube rests on an erection tower preparatory to installation of the lower truss members of the tube. The declination gear shows at the right. The preload pulley is now in place on the west arm of the fork. The preload will be applied through a ⅜-inch wire rope led down to a weight running on rails inside the polar axle.

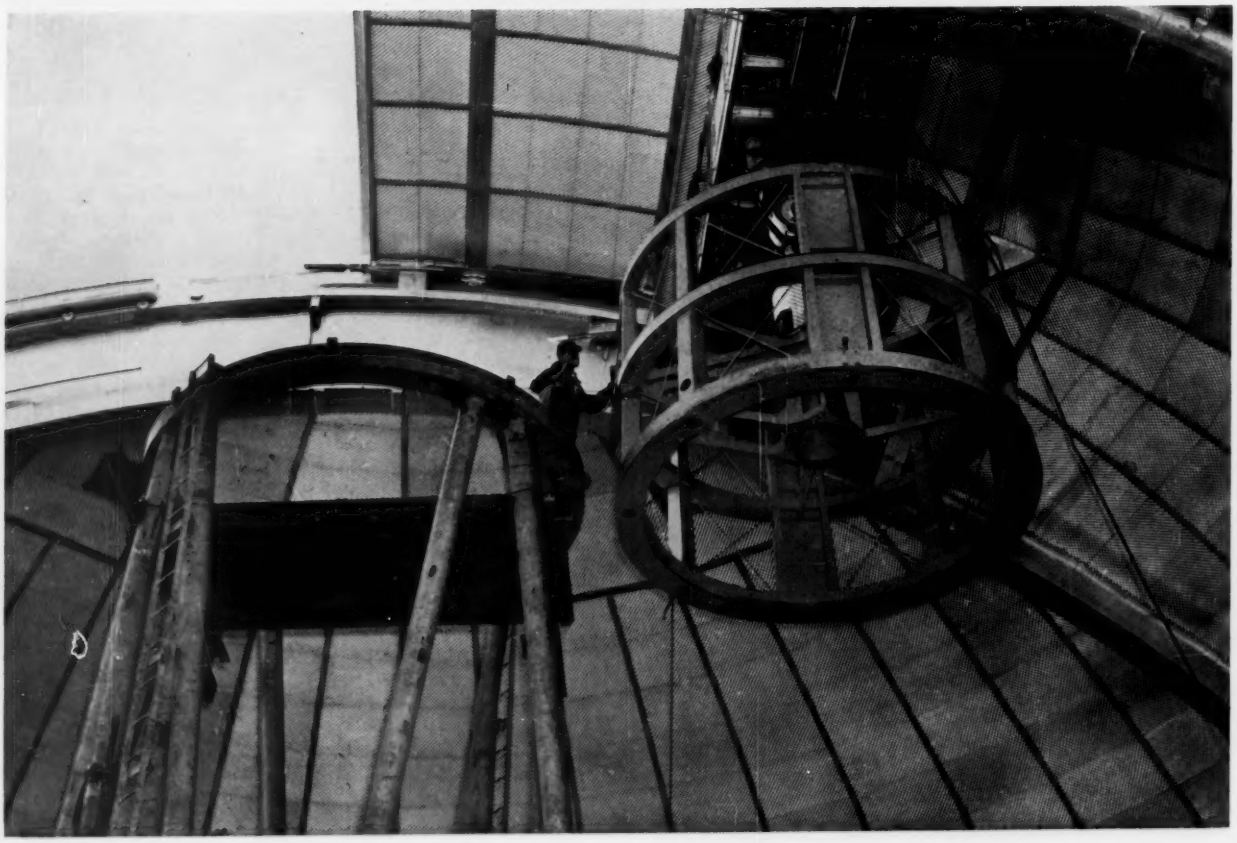


Above: July 15, 1954. The upper section of the telescope tube, which was preassembled on the working floor, is being installed. All of the truss members are tubes eight inches in outside diameter. The long upper tubes have wall thicknesses of 11/16 inch; the short lower tubes are ¼-inch thick.

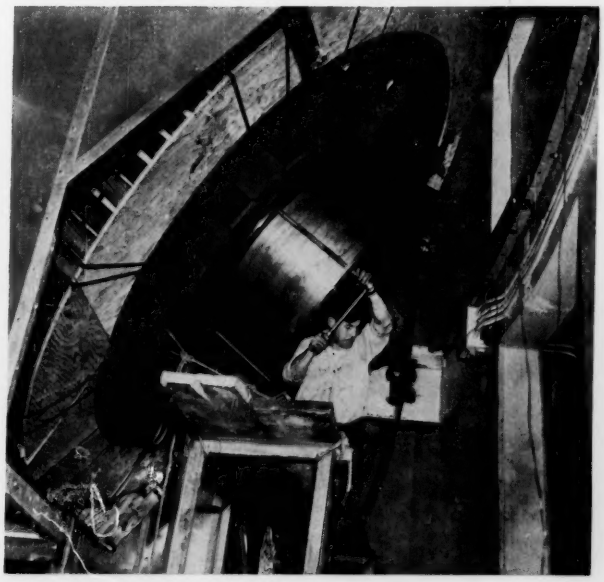


Left: August 5, 1954. The prime-focus unit with the observer's cage in place rests on the observatory floor before installation. The cage and the tube containing optical parts have separate spider support systems. The observer's cage turns on an 18-inch-diameter ball bearing centered on the optical axis and supported by the spider system for the cell. The observer's cage is rotated around the optical cell by means of an electric motor, to provide convenient observing positions. Because the observer's cage is placed well off center, it must be counterweighted by the 80-pound flat weight seen outside the center ring girder at the right in the picture. Small black sprockets, along the upper side of the center ring, support the chain that is geared to the observer's cage to control the motion of the counterweight around the outside of the prime-focus unit.

Below: August 9, 1954. The prime-focus unit has been hoisted to the top of the dome by the overhead crane; it will soon be placed on the upper end of the telescope tube. After the telescope is in use, the prime-focus unit will be removed by this procedure whenever it is to be replaced with the coude secondary support unit. At the upper left the partly opened overhead shutter of the dome shows the sky.

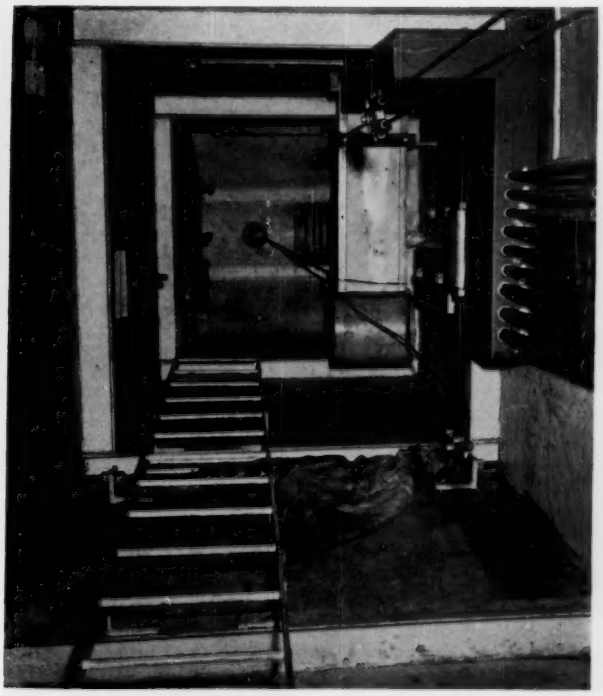


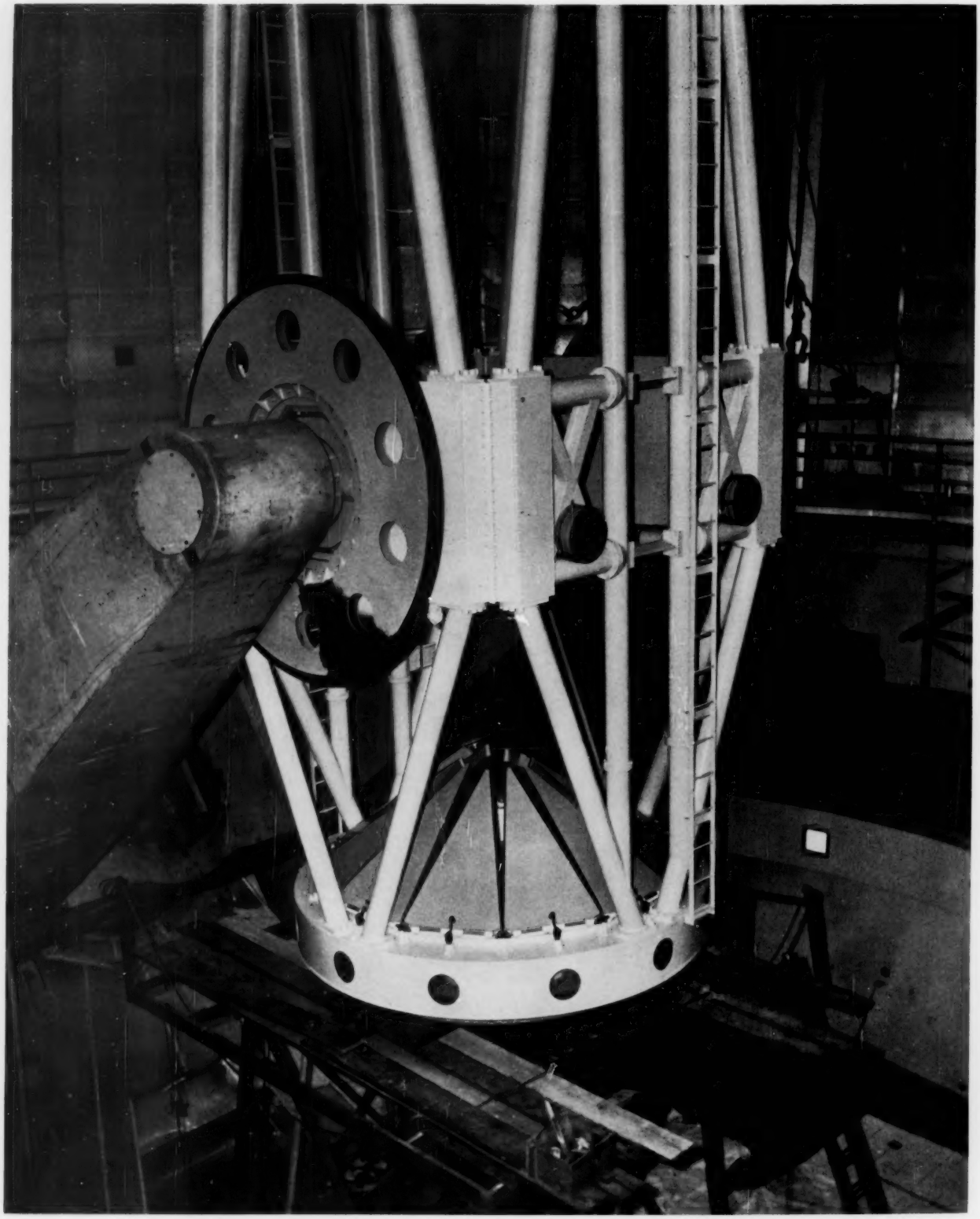
September 22, 1954. Gleaming aluminum encases the polar-axle bearing system and right-ascension machinery at the north end of the telescope mounting. Instead of having individual covers for each component, the entire base is enclosed in this tight housing. To prevent the entrance of dust and undesirable changes in humidity, filtered air will be pumped into the housing to supply a slight amount of outward pressure. The opening in front of the workmen is for the telescope control console. Two long vertical tubes (center and left) are safety struts that lock the fork in place whenever the telescope may be in an unbalanced condition, for instance, when the mirror cell is removed. At the top left, a short horizontal portion of another safety strut can be seen; this ties the bottom of the tube to the center of the fork yoke. The struts will be removed for operation of the telescope, but they can be reinserted whenever necessary, as during interchanging of the prime-focus and coude secondary units.



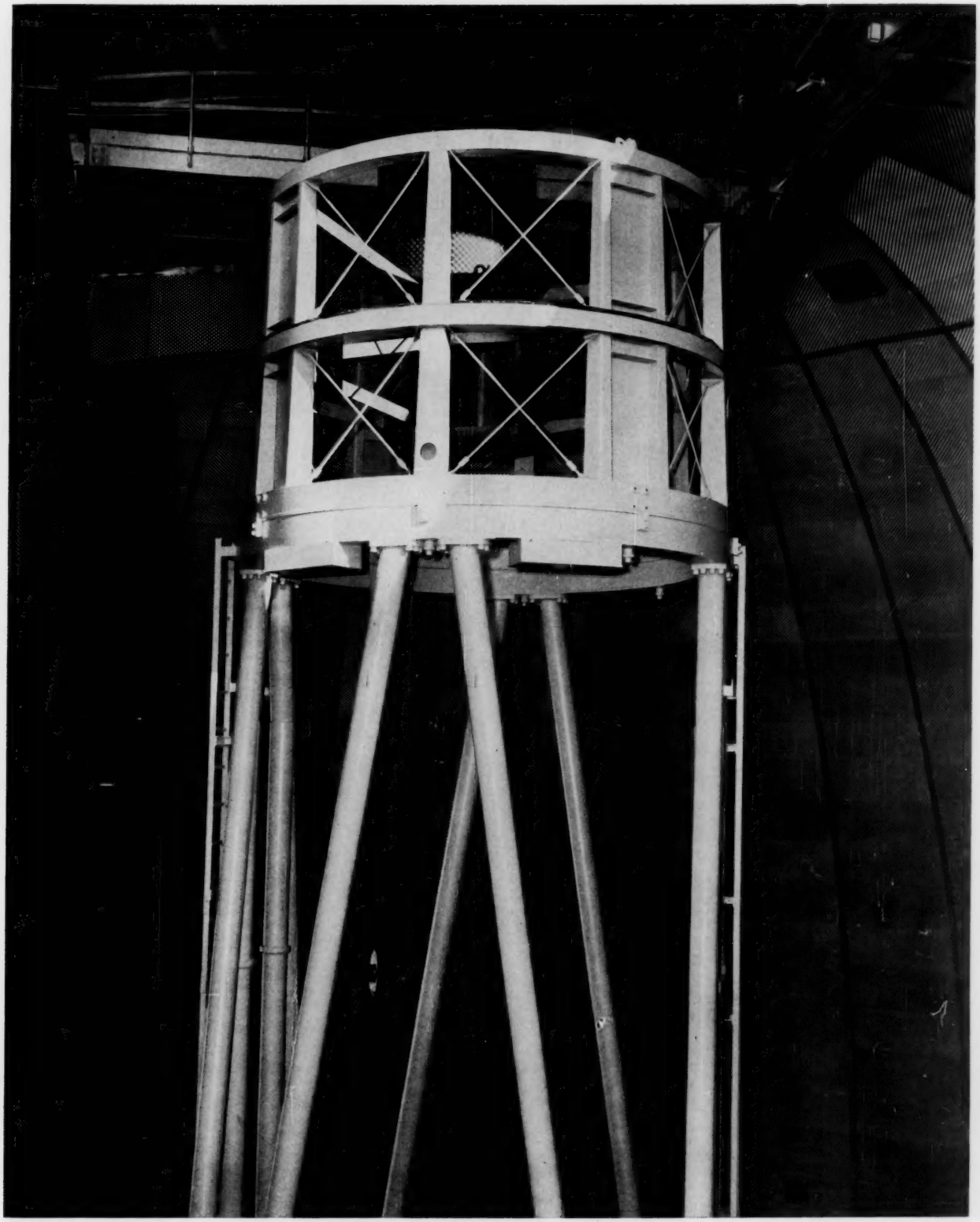
Above: October 11, 1954. The large right-ascension driving gear, shown in the picture of January 19, 1954, is being installed at the lower end of the polar axle. The installation cylinder was originally placed inside the gear and was temporarily bolted to the polar axle to form a smooth surface over which the gear rode when being jacked by means of four long screws. The workman has turned these four screws until the gear has slipped nearly into place, and the surface of the installation mandrel is now exposed. The opening of the coude room is seen at the right.

Below: November 10, 1954. In this picture inside the west fork arm, we see the slack adjuster for the electrical control cables that lead upward through the declination axis to the telescope tube. In the upper right, the declination preload cable extends to the weight in the polar axle. The interior of the east fork arm is shown in one of the photographs of May 7, 1954.

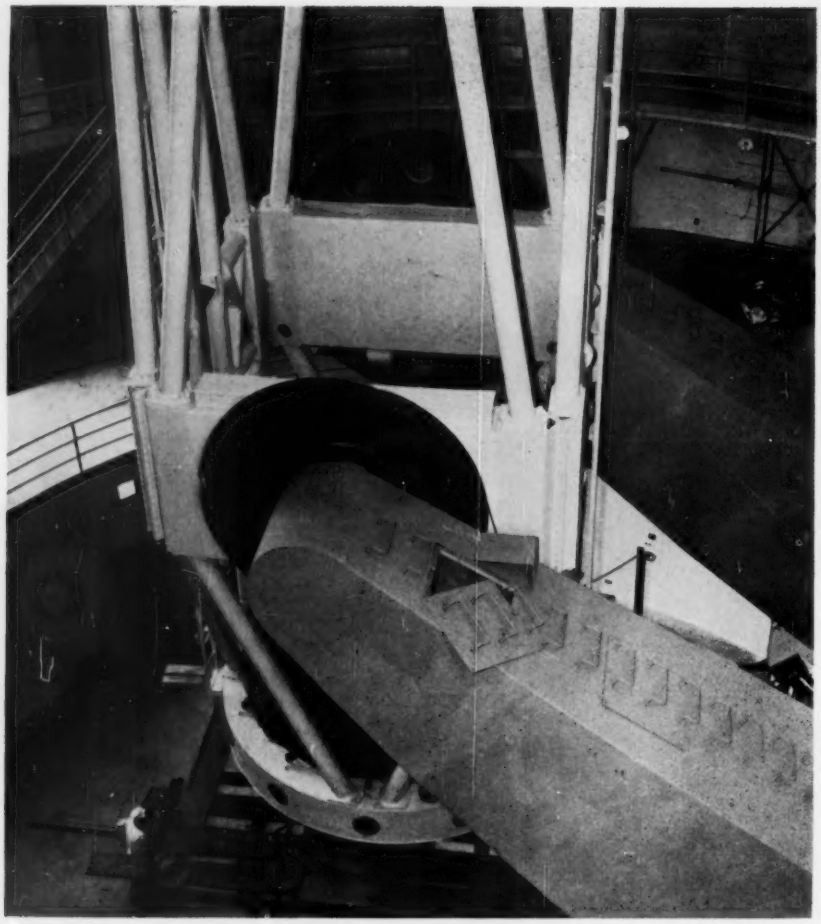




November 10, 1954. With the mechanical parts of telescope and mounting virtually complete, the declination gear is being painted. The mounting point of the instrument is one quarter of the way up the tube. The 12-sector aluminum mirror cover, here partially open, is operated by a worm and chain drive from a motor in the lower ring girder. This is storage-battery operated so the mirror may be covered in the event of power failure. On the north and south sides of the telescope framework are parallel vertical tubes, braced by narrow fins. On the south side (left rear in this picture) these tubes border the slot through which light must pass to the coude focus; the slot on the near side is for symmetry. In one of these tubes the position of a sliding 200-pound counterweight will be set from the console, to balance the telescope along its length for differing weights of observers at the prime focus and for minor changes in instrumentation.

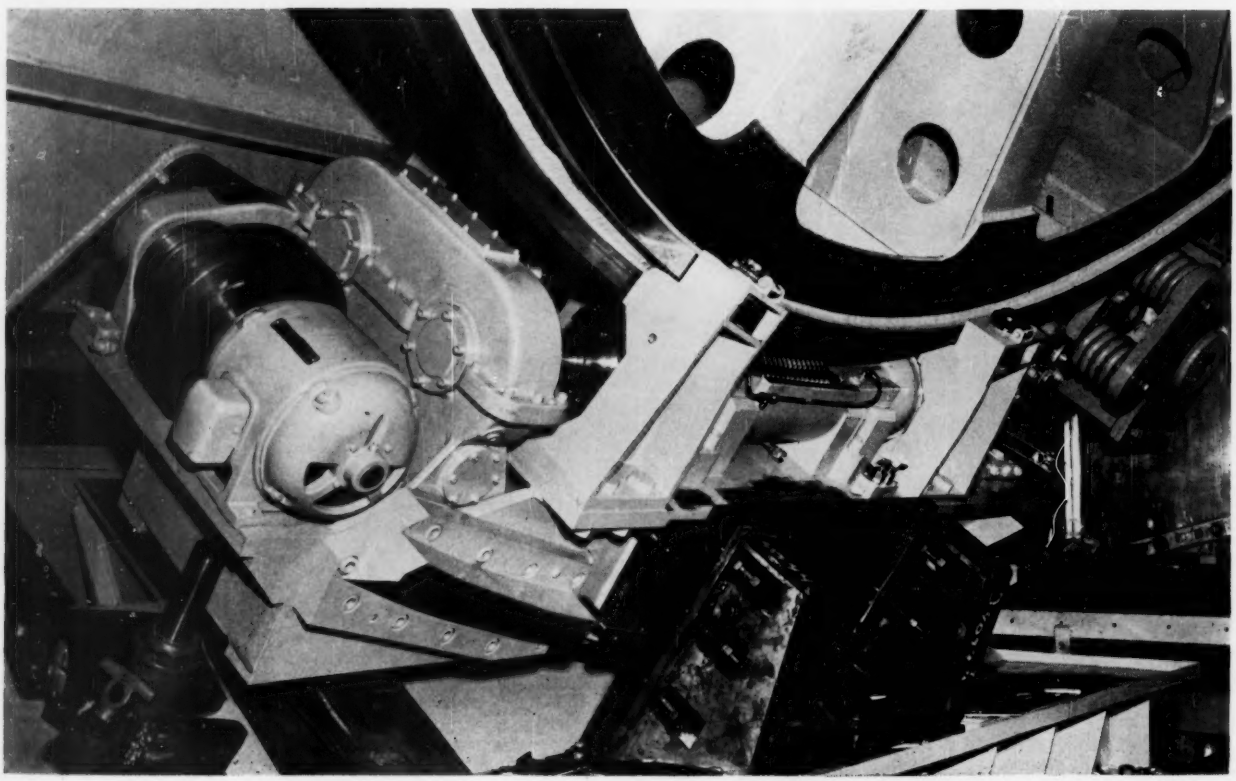


December 16, 1954. The upper end of the telescope tube, with the prime-focus unit in position. The entire length of the instrument is 50 feet, from the bottom of the mirror ring girder shown opposite to the upper end of the prime-focus unit. The total weight of the tube assembly, including the mirror, will be almost 40 tons. The 120-inch mirror itself is not installed – a slab of cement of about its weight takes its place to keep the instrument in balance. Preliminary grinding of the mirror had been completed in the spring of 1954, to about 0.02 inch of the desired depth and to within about half an inch of the edge of the disk. About 800 pounds of glass were removed by the rough grinding. Another 22 pounds will be taken off during fine grinding, polishing, and figuring. During early 1955, further work on the mirror is taking place and burnishing of the right-ascension worm gears is under way.



Left: December 16, 1954. The action of the declination preload is shown here, on the west (near) side of the square center section of the telescope tube. The preload sheave (pulley) has fastened to it on the left side a $\frac{3}{8}$-inch wire rope, which runs over the pulley and into the west fork arm; a short section of the cable is seen beyond the partially open hatch in the arm. The weight attached to this cable holds it taut, preventing backlash in the operation of the declination gear. Painting of the mounting and tube is almost complete. The tube is bright yellow, the declination gear and preload sheave are terra-cotta red, and the fork arms an olive brown.

Below: December 16, 1954. This is a view of the right-ascension driving mechanism. In the upper part of the picture is the large right-ascension gear wheel, which has welded to its rim two worm gear rings, each having a $3\frac{1}{8}$-inch-square cross-section. With a diameter of 148 inches, each gear ring contains 720 teeth. The $1\frac{1}{2}$-horsepower motor at the left is the fast-motion drive; this engages the nearer worm, visible to right of center. Behind this worm is another, for slow motion, driven by a 1/25-horsepower motor. This motor plus the setting and guide motors are located up inside the housing, and cannot be seen here. The worms are interconnected, but at any time only one worm has its end thrust restrained, by means of a pin clutch; when one is driving, the other worm stays in step but is floating in the system.



The Duplicity of Nova Herculis

OTTO STRUVE, *Leuschner Observatory, University of California*

ON DECEMBER 13, 1934, an English meteor observer, J. P. M. Prentice, discovered a naked-eye star not far from Vega where there had been none before. By December 22nd, this star had reached a maximum brilliance of magnitude 1.3, and was about 300,000 times its normal prenova brightness of magnitude 15.

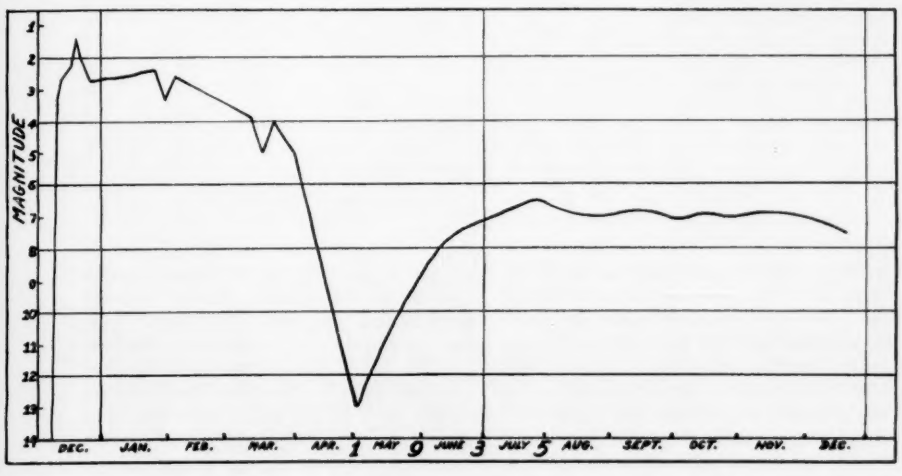
After months of erratic fluctuations, Nova Herculis suddenly began to fade rapidly in March, 1935, sinking to magnitude 13 in a month, and brightening once more to 8 by May. Since then the star has slowly faded, and has now sunk to the 14th magnitude. This behavior is strikingly similar to that of Nova Aurigae 1891, which rose from magnitude 16 to 4, and required 33 years to return to its original faintness.

Today Nova Herculis, also known as DQ Herculis, is of great interest to astronomers because it has been found to be an eclipsing double star, the only known case of its kind among the novae.

During the summer of 1954, at Mount Wilson Observatory, Dr. Merle Walker was engaged in a photoelectric study of the light variations of several old novae. His purpose was to see if these stars exhibited rapid, flarelike changes in brightness. In the case of DQ Herculis, he found such changes on several nights.

Similar but less pronounced flares had already been detected in one or two other nova-like objects, and in several under-

Nova Herculis is at the center of this portion of a Harvard Observatory patrol plate, an 82-minute exposure on March 13, 1935, when the nova had faded to about 4th magnitude. Of similar brightness is Iota Herculis, over an inch to the right of the nova. Vega is very bright in the lower left, and near it is the elongated image of the double-double star, Epsilon Lyrae.

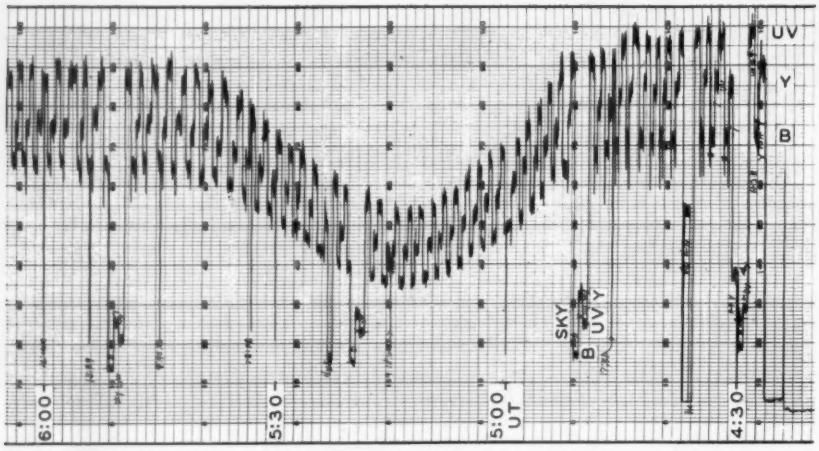


A smoothed light curve of Nova Herculis from December, 1934, to the end of 1935. The great minimum during the spring matched that of Nova Aurigae 1891.

luminous very blue stars of the Humason-Zwicky type. The latter are probably old stars that have exhausted their atomic hydrogen fuel and are now shedding matter as a preliminary to becoming collapsed white dwarfs. Stars that become novae, such as the prenova state of Nova Herculis, are also subluminous.

But in the course of his work, Walker made a totally unexpected discovery: Nova Herculis is an eclipsing variable with a depth of primary eclipse of 1.3 magnitudes in yellow light (see *Sky and Telescope*, January, 1955, page 101). The interval between successive eclipses is 4 hours 39 minutes; this is the shortest period of any double star known at the present time, but it is only four minutes shorter than the period of UX Ursae Majoris, one of the most remarkable binaries in the sky. The similarities of these stars invite further consideration.

Both systems have light curves of the



These photoelectric tracings of Nova Herculis were obtained by M. Walker during a primary eclipse on August 1, 1954. The blue observations (B) were made with a lower sensitivity setting of the photometer than that used for the deflections in ultraviolet (UV) and yellow (Y) light. Courtesy, Mount Wilson and Palomar Observatories.

Algol type. That is, between the minima the light is practically constant, except for the small intrinsic fluctuations which, in the case of UX Ursae Majoris, were discovered first by W. A. Hiltner, at the McDonald Observatory some 10 years ago, and were independently observed at Harvard by A. P. Linnell and at Mount Wilson by Walker.

Neither system shows any trace of a secondary eclipse. It might be supposed that the period is really twice as long as the interval between eclipses, and that every other eclipse is really a secondary indistinguishable from primary eclipse. This is impossible—identical secondary and primary eclipses cannot be deeper than three quarters of a magnitude. Hence, the period really is 4 hours 39 minutes and the secondary eclipse is unobserved. This indicates that the surface brightness of the secondary component (which is in front of the primary during the principal eclipse) is much lower than that of the primary star.

One of Walker's original tracings of DQ Herculis is shown above. Since the principal minimum is not flat-bottomed, the eclipse is partial. The eclipse lasts about one hour, but it is not entirely symmetrical. The amplitude is 0.9 magnitude in ultraviolet light, considerably less than in yellow light. If interpreted in the conventional manner, this would suggest that the darker star, in front, is the bluer of the two. But Walker is inclined to attribute this effect to the filling in of the light curve, in blue and ultraviolet light, by radiation from the nebulosity surrounding the two stars. It is therefore probable that the darker component is actually also the redder, as is the case with UX Ursae Majoris.

In both systems, the shape of the principal minimum is variable. On some nights, Walker observed a brightening of almost 0.1 magnitude immediately before the onset of eclipse. There were also changes in the degree of asymmetry of the principal minimum. Both the bright shoulder and asymmetry occur, and vary in amount, in UX Ursae Majoris.

The photometric orbit of Nova Herculis has not yet been calculated from its light curve. But from the similarity of the two light curves, we may infer that the orbital elements must resemble rather closely those of UX Ursae Majoris. Several orbits for the latter have been derived, but all of them are uncertain because of the peculiar features of the light curve that are unexplained by the geometrical theory of eclipsing binaries. In 1949, P. P. Parenago adopted the following values for UX Ursae Majoris:

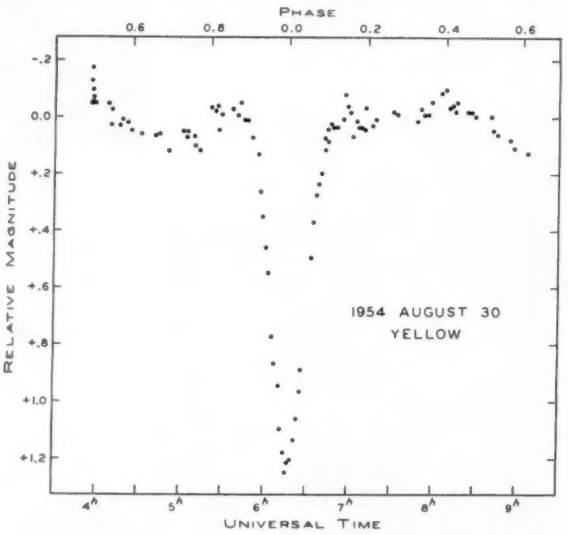
Each component has a radius of 0.2 the distance between them, which is two million kilometers. The apparent magnitude of the primary is 12, of the secondary, 14. Their orbital plane is inclined 85 degrees to the plane of the sky, or five degrees to the line of sight.

The spectrum of the primary star is very early *B* (or even *O*, according to G. Herbig), while the secondary star's spectrum has not been observed. Parenago suggests that it may have a surface temperature like that of an *A* star, about 11,000° K.

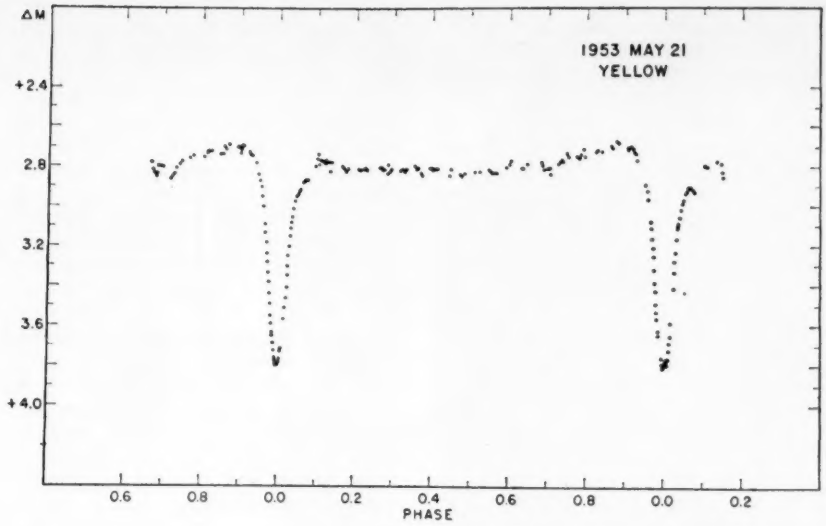
Both components are about half as large as the sun. Since their masses are three and two times that of the sun, their average densities are about 25 and 15 times the sun's, respectively—almost 100 times denser than normal for stars on the main sequence of the spectrum-luminosity diagram.

Each of these stars is strikingly underluminous for its mass and spectrum. The visual absolute magnitude of the primary is +3, but a normal star of spectral type *B*0 is about −2, which is 100 times brighter. However, the components of UX Ursae Majoris are not real white dwarfs, but objects intermediate between main-sequence stars and white dwarfs. They are *subdwarfs*.

Recently, Walker and Herbig have proposed a tentative model of UX Ursae Majoris that is shown opposite. A cloud of gas is thought to be asymmetrically located in the vicinity of the brighter star, as first proposed by Linnell. This hot, luminous cloud produces the shoulder of the light curve preceding primary eclipses, but is also associated with a cooler layer of gas that affects the light curve and the spectrum chiefly from phases 0.4 to 0.9 of the period of the binary. Walker and Herbig point out the possibility of changes in nature and position of these hypothetical gas clouds.



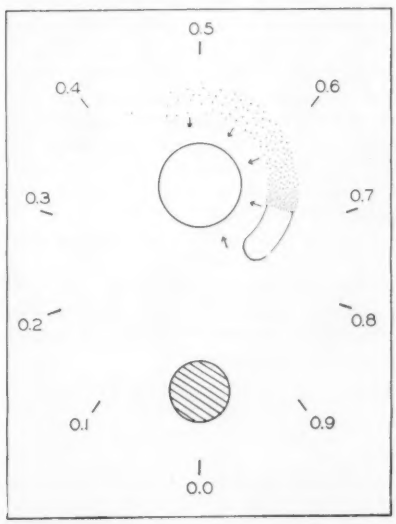
From a tracing in yellow light similar to those above, Dr. Walker obtained this light curve of a minimum of Nova Herculis on August 30, 1954. Note the rapidity of the light changes, sometimes five magnitudes an hour, and the rise in brightness just before descent into eclipse. Courtesy, Mount Wilson and Palomar Observatories.



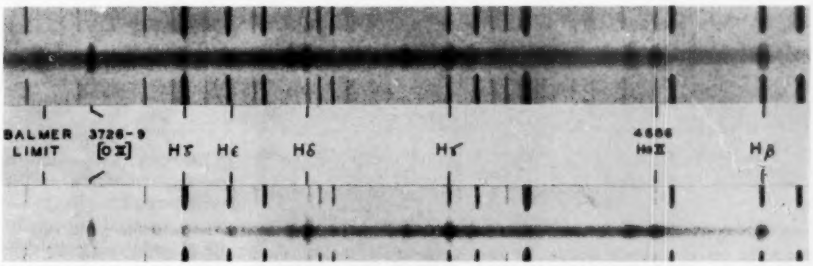
Using the 60-inch reflector at Mount Wilson Observatory, Dr. Walker obtained this night's run of photoelectric observations of UX Ursae Majoris, covering 1½ cycles of its light variation. From the "Astrophysical Journal."

As for Nova Herculis, the present spectrum yields little new information. Two of the recent photographs taken by M. Humason at Mount Palomar are shown here. The strong emission lines come from the still expanding shell of the nova outburst 20 years ago; they do not show periodic velocity displacements consistent with the $4\frac{2}{3}$-hour cycle of the binary and thus are not directly associated with the double star motion.

On the other hand, the continuous spectrum is strong—most of the system's light at the present time comes from one component of the binary, not from the gaseous shell. There are no distinct absorption lines, such as we see in a normal stellar spectrum like the sun's, caused by elements in the reversing layer of the atmosphere of the star.



In this proposed model of UX Ursae Majoris, the direction to the earth is marked at phase intervals of a tenth of the period, beginning with mid-eclipse. When the bright, detached gas cloud is hidden by the faint star, at phases 0.03 to 0.1, the rising branch of the light curve is depressed. From the "Astrophysical Journal."



Two spectra of Nova Herculis 1934, the upper taken at phase 0.07 and the lower at phase 0.6 of the light curve, by M. Humason with the 200-inch telescope. This reproduction is a negative, on which emission (bright) lines appear dark; these arise from the nebular shell, while the strong continuous background is from the nova itself. Each nova spectrum is flanked by bright-line comparison spectra.

The discovery of the duplicity of Nova Herculis raises several interesting questions: Is this an accidental occurrence or are, perhaps, all novae close double stars? Was the star double prior to its outburst as the nova of 1934, or did fission occur during the outburst? If it was a binary long before the nova event, what were its characteristics during its earlier history? Does the similarity of the Nova Herculis and UX Ursae Majoris systems imply that the latter is also a former nova?

It is impossible to answer these questions definitely now, but let us consider the possibility that all novae are close double stars. In no other case has a post-nova been found to be a short-period eclipsing binary. Because those postnovae with strong nebular emission lines shine mostly by light from the expanding shell, they would not be expected to show the eclipses even if the latter were to occur. Similarly, all novae at the time of maximum brightness may be ruled out.

However, Humason, P. Swings, the writer, and others have shown that a number of old novae have strong continuous spectra which presumably originate in the photospheric layer of the star, or of the two stars if they are binaries. These old novae have been extensively observed visually by W. H. Steavenson in England, and a few have also been studied by photographic and photoelectric means. Eclipses one magnitude deep would probably have been detected, if they occur. But an eclipse can be seen only if the plane of the binary orbit lies nearly in the line of sight—it is within five degrees in the case of UX Ursae Majoris. Five out of six binaries would on the average be inclined more than 10 degrees from the line of sight and would not be expected to show observable eclipses.

We might discover a star's binary nature by the periodic Doppler shift of its spectral lines—it is then a spectroscopic binary. But most old novae have extremely weak and diffuse absorption lines, and many are too faint for high-dispersion spectrographic studies.

On observational grounds, therefore, it is possible that all novae are close double stars, but only in the case of DQ Herculis have we any definite evidence to this effect. However, several nova-like variables are probably double stars. The famous recurring nova, T Coronae Borealis, which blazed up in both 1866 and 1946, has a composite continuous spectrum, indicating that the star has two components of different spectral types. Also, A. H. Joy recently discovered the nova-like star AE Aquarii to be a close spectroscopic binary with a period of a little more than one day. It appears plausible that binaries are common among the recurring novae and nova-like stars.

Of course, binaries are also frequent among the stars in general, and if they had the same relative abundance among

stars that become novae we would conclude that the phenomenon of nova outburst is unrelated to binary nature—such an outburst would occur whenever the internal conditions in either of the component stars required it.

I suggest that many astronomers would be inclined to accept this latter alternative rather than believe that the nova phenomenon is restricted to close binaries. There is also good reason to discard the theory that fission occurs at the time of the nova explosion. A normal nova outburst is skin deep—the nova sheds only about 1/1,000 of its mass, according to D. B. McLaughlin's exhaustive studies. It is unlikely that such a relatively superficial phenomenon should result in the creation of a double star!

The belief that any single star of sufficiently large mass will ultimately go through the process of a nova explosion has a basis in the current theory of evolution of single stars. The chart has been sketched in accordance with the general trend of evolutionary tracks prepared by L. G. Henyey and his co-workers at the Leuschner Observatory.

Suppose the star, to begin with, had a mass two or three times that of the sun. It will at first contract, but this stage can last only about one million years. As the internal thermonuclear processes begin to operate the star changes more slowly, remaining on or near the main sequence for a long period of time before it gradually develops into a red giant.

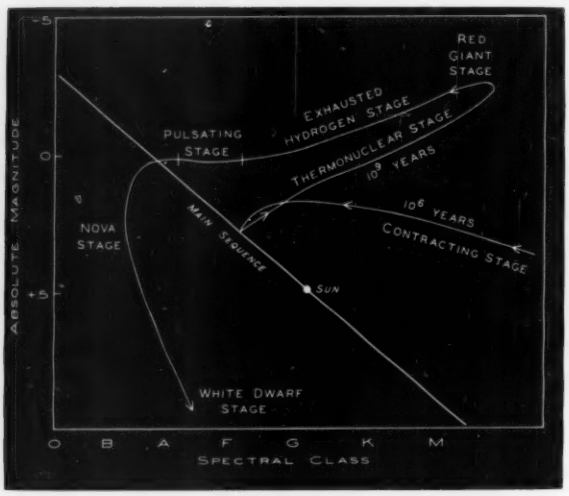
After the available hydrogen in the core of the star has been converted into helium, the surface temperature begins to increase and the star runs through a pulsating stage at absolute magnitude zero. This leads to a stage in which it is an underluminous, blue star of the Humason-Zwicky type. It begins to shed material on its downward evolutionary course, and becomes ultimately a white dwarf of about one solar mass. The shedding of the material is the nova stage, and the nova outbursts are repeated at more-or-less frequent intervals.

If this picture of the evolution of a single star is correct, the binary nature of Nova Herculis would be immaterial. But the exhausted hydrogen, pulsating, and nova stages are at present rather uncertain extrapolations of the better-established thermonuclear stage. Perhaps we may have to revise the picture completely, in which case it may turn out that the binary character of a nova does play an important role in its evolutionary process.

Assuming Nova Herculis to have been a double star before its outburst, what was the effect of this event on the binary system? McLaughlin has described in detail the character of a nova outburst (*Popular Astronomy*, February, 1950, page 50). For the first few hours or days of the outburst the binary revolved in an *atmosphere* whose density may have been comparable to that of the outer layers of a supergiant star like Epsilon Aurigae. It is almost certain, however, that the time was too short for this resisting medium to produce any perceptible effect upon the orbital motion of the binary. Of course, there were several successive explosions, and during a few months or years the double star revolved inside a tenuous *nebula*. But even this longer interval of time would not suffice to alter the orbit appreciably.

A striking difficulty, suggested to Dr. Walker by W. A. Baade, arises if we trace back the history of Nova Herculis a billion years or so, to the red-giant stage in the diagram. Presumably at least one component was a red giant much larger than the present orbit of the entire system. If the radius of the giant star were then 22 times the sun's present dimension, its mean density would have been 1/5,000 that of the sun. It is inconceivable that the binary could have revolved inside this relatively dense medium for millions of years without amalgamating into a single star. Either the star was not a binary at all at that time, or its separation was about 20 times greater and its period correspondingly longer than it is now.

The latter alternative is not as untenable as it may appear at first sight. If, to begin with, the double star were really a normal spectroscopic binary with a total mass of five suns and a period of about five days, the separation between the components would have been ample for the entire evolutionary history of the system, except the red-giant stage. In that stage, then, one of the components may have grown enough to obstruct the orbital motion of its companion, and the latter would have spiraled toward the center of the red giant in gradually diminishing loops and with a corresponding shortening of the period. Thereafter the binary system would have its present compactness and short period.



The nova phenomenon may occur when a star with certain characteristics is well along in its evolutionary history. This diagram shows the possibility that such a star may occupy many parts of the spectrum-luminosity diagram before shedding matter as a nova and becoming a very dense degenerate star—a white dwarf.

LETTERS

Sir:

When did Newton discover the law of gravitation, which was first published in 1687? In Andrade's *Sir Isaac Newton* (reviewed in the March issue), as in most other books on Newton, this question is glossed over. It is usual to accept Newton's own statement, made in his old age, that 1666 was the year of discovery. This traditional account tells that his early attempt at that time to verify the law numerically failed, owing to the use of an inexact figure for the size of the earth.

One fact, however, contradicts 1666 as the year of discovery. Newton was present at the meeting of the Royal Society in 1672, when the new and nearly correct determination of the size of the earth by the French astronomer Picard was presented. It seems unbelievable that, had Newton already conceived the law of universal gravitation, he would have failed to take immediate advantage of this key to his problem, instead of waiting more than a decade before announcing its import.

It seems much more reasonable to conclude that the traditional account is wrong and that discovery of the law happened between 1684 and 1687, during the writing of the *Principia* in which it was first announced.

SERGEI GAPOSCHKIN
Harvard College Observatory

Sir:

With a needle I have carefully punched additional holes in my Spitz Jr. Planetarium, using the monthly star charts in *Sky and Telescope*. I record such objects as the Andromeda nebula and the Double Cluster in Perseus by punching a series of five or six tiny holes close together. The effect is very real.

ROBERT M. ADAMS
324 S. Valley
Neosho, Mo.

How Long Totality?

The preceding total eclipse of the same saros series as this year's June eclipse was on June 8, 1937. This photograph was made by Fernando de Romana at Huangra, Peru, with a 6-inch f/16 refractor. The irregularity of outline and absence of very long equatorial streamers are typical of coronas photographed near sunspot maximum.

NEXT MONTH'S total eclipse of the sun, on June 20th, is remarkable for the long duration of totality, over seven minutes at some stations. Pages 142 and 143 of *Sky and Telescope*, February, 1955, give a map and description of the region of visibility for this eclipse, which will not be exceeded in duration of totality for 213 years.

What circumstances decide the length of time the sun is totally eclipsed at a given station? Many factors are involved, and to understand our discussion of them the reader may wish to review the eclipse section of his favorite textbook, or to read Chapters III and IV in the fifth edition of S. A. Mitchell's book, *Eclipses of the Sun* (Columbia University Press, 1951). For convenience, our article has its own special glossary.

Of greatest importance in the duration of totality are the distances from moon to earth and from earth to sun; the position of the shadow path with reference to the earth's equator and the declination of the sun; the rotation and curvature of the earth; the nearness of the sun to a node of the moon's orbit; and the location of the observer with respect to eclipse noon and the central line of the moon's shadow.

Consecutive eclipses in the series that constitutes a saros occur at intervals of 223 synodic months—a little more than 18 years. As the table shows, the eclipses of a saros series recur under nearly similar circumstances. With each additional eclipse in the same saros, the sun's position is advanced easterly along the ecliptic by about 10.5 degrees. But the moon's node and its perigee point do not stay fixed. The node is moving westward (in a 19-year period), and the shift in the sun's celestial longitude with respect to it is only 28 minutes of arc at each succeeding saros interval. The perigee point of the moon's orbit moves eastward (in a nine-year period) and the sun is 2.8 degrees farther west of the perigee at each eclipse of the series, on the average. All of these motions, which are somewhat nonuniform, change the duration of totality from eclipse to eclipse as the saros progresses.

This duration reaches a maximum near the middle of the long progression of a saros series. Notice in the table that the increase in the duration has tapered off. The next eclipse in the series, in 1973, will be total for very nearly as long as the one this year. At the following eclipse, in 1991, the duration of totality will be shorter. Thus, this series will fail to produce an eclipse in which the longest possible totality—about seven minutes and 31 seconds—is reached.

TOTAL ECLIPSES IN THE SAME SAROS SERIES AS THAT OF 1955

Date	*Sun's declination*	**Latitude*	**Difference*	**Duration*
1811 March 24	1° north	39° south	40°	3.4 min.
1829 April 3	5° "	32° "	37°	4.1 "
1847 April 15	9° "	24° "	33°	4.7 "
1865 April 25	13° "	16° "	29°	5.3 "
1883 May 6	16° "	9° "	25°	6.0 "
1901 May 18	19° "	2° "	21°	6.5 "
1919 May 29	21° "	4° north	17°	6.9 "
1937 June 8	23° "	10° "	13°	7.1 "
1955 June 20	23° "	15° "	8°	7.2 "
1973 June 30	23° "	19° "	4°	7.2 "
1991 July 11	22° "	22° "	0°	7.1 "

* The *latitude* is for the point on the earth's surface at which the eclipse is central at noon. The *difference* is the corresponding zenith distance of the eclipsed sun. The *duration* of totality to the nearest tenth of a minute is given for the noon point (according to Simon Newcomb), where the duration is sometimes 0.1 minute less than the maximum for that eclipse.

Apparent size of the moon. When the moon is at perigee and the earth at aphelion, the excess of the moon's apparent diameter over the sun's is greatest. At the 1919, 1937, and 1955 eclipses, our satellite is successively closer to the earth; therefore, the eclipses should become longer. At the June 20th eclipse, the moon is eight degrees east of perigee, and the average shift in one saros interval is 2.8 degrees westward. The position with respect to perigee is, therefore, still becoming more favorable, but this is not the only factor involved in what the actual value of perigee will be at future eclipses in the series.

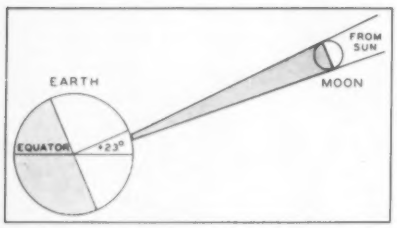
Apparent size of the sun. When the earth is at its greatest distance from the sun, on about July 4th each year, the sun has its least apparent size. The eclipse

of June 30, 1973, is most favorable in this respect. Later eclipses in the series occur with the earth farther from aphelion.

Declination of the sun. Because the earth must be near aphelion, the longest eclipses occur in June and July, when the sun has a far northerly declination. On July 4th, the sun's declination is about +23°. If the earth did not rotate, the longest duration of totality would occur at a point directly beneath the sun, in other words, at latitude 23° north. (When the sun is eclipsed on June 20th, near the time of the summer solstice, the sun will have a declination of nearly +23½°.)

Rotation of the earth. The eastward motion of the observer with the rotating earth changes the case, however, for the moon's shadow overtakes the observer more slowly than if there were no rotation. The velocity of rotation is greatest at the equator, about 1,040 miles an hour, whereas at 23° north latitude it is noticeably less, about 960 miles an hour. Thus, the effect of the rotation in retarding the apparent eastward motion of the shadow is greatest at the equator.

The longest eclipses do not occur at the equator, because of the sun's northerly declination when it is near aphelion, but they also do not occur at 23° north latitude, because of the rotation effect. The optimum case is represented by the diagram, where the shadow of the moon falls at some latitude between these extremes.

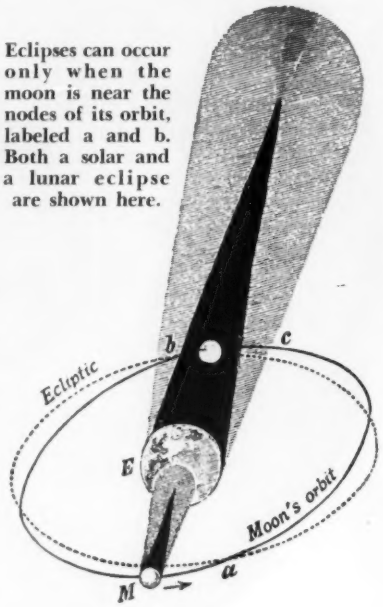


The longest possible duration of totality can occur only at a latitude intermediate between 0° and 23° north.

Curvature of the earth. Ideally, the observer with the sun and moon in his zenith is favored because the moon's conical shadow has the largest cross-section where it strikes the earth. With the sun at declination 23° north and the moon's shadow falling at the equator, the shadow there would have a smaller cross-section. This would reduce the duration of totality, in spite of the effect of the earth's rotation being greatest at the equator. In this case, also, the balance between these two effects is reached at an intermediate latitude.

Nearness to the moon's node. Early in a saros series, the moon and sun are far from the node, and the moon's shadow falls obliquely on one of the polar regions of the earth. It is the approach to the node that causes the eclipse saros to progress from the pole to equatorial regions, while the eclipses in the series become longer.

Eclipses can occur only when the moon is near the nodes of its orbit, labeled a and b. Both a solar and a lunar eclipse are shown here.



In 1955, the station where the eclipse is central at apparent noon is south of the point beneath the sun, but the difference lessens as the saros progresses, as shown in the table. This is because these eclipses take place when the moon is east of its descending node, hence south of the ecliptic, and each eclipse finds our satellite a little nearer the node and the ecliptic than before.

To procure the largest shadow cross-section, the sun and moon should be in the observer's zenith, and this requires that they both be at the node at mid-eclipse. But, as we have seen, the rotation factor requires that the shadow fall well south of the subsolar point. This puts the moon south of the sun in the sky, and they cannot be at the node.

Which node? The actual conditions for the longest totality are shown schematically in the diagram. The sun is slightly east of the longitude corresponding to aphelion, while the moon is at perigee but west of the ascending node.

Since the declination of the sun is decreasing slightly at aphelion in July, the change in the moon's declination is less near the ascending node than it would be near the descending node. This results in the shadow-path motion being more nearly eastward across the surface at the noon point, so the retardation of the earth's rotation on the speed of the shadow is greater.

Observer's position. Both the rotation and curvature of the earth factors indicate that an observer placed where the eclipse occurs near local noon will have the longest duration of totality. It is also obvious that the observer should be on the central line of the shadow path.

Favorable though it is, the saros series of the June eclipse cannot reach the theoretical maximum duration. One of the reasons is that it is a descending node series. Another is that the most favorable latitude of the noon point is not achieved in combination with the other factors, such as perigee-aphelion, for any one eclipse.

At the time of the eclipse of July 6, 2168, conditions will approximate those of the optimum shown in the node diagram, and the eclipse will be within three seconds of maximum duration. The most recent eclipse in this series was the one on February 25, 1952, successfully observed at Khartoum. The next eclipse in this series will touch the coasts of Florida, Georgia, and Nova Scotia on March 7, 1970.

SOME TERMS IN THIS ARTICLE

APHELION (of the earth): The point in the earth's orbit farthest from the sun.

CELESTIAL LONGITUDE: A co-ordinate measured eastward along the ecliptic from the vernal equinox.

DECLINATION: A co-ordinate in the sky measured north or south of the celestial equator, corresponding to terrestrial latitude.

ECLIPTIC: The apparent annual path of the sun around the sky.

NODE (of the moon): One of two points in the sky where the moon's orbit intersects the ecliptic. At the ascending node, the moon crosses the ecliptic from south to north; half a month later, at the descending node, it crosses from north to south.

PERIGEE: The point in the moon's path nearest the earth.

SAROS SERIES: A succession of eclipses that occur at intervals of 18 years and 10⅓ or 11⅓ days.

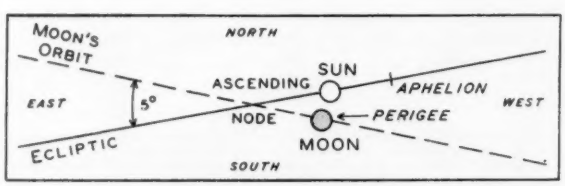
SHADOW PATH: The trace of the moon's umbra on the earth during a total solar eclipse. Only within the shadow path can totality be seen.

SYNODIC MONTH: The month of the moon's phases, averaging 29½ days in length.

TOTALITY: The interval during a total solar eclipse when the moon completely hides the sun's main body or photosphere.

Ed. Note: The basic material and diagrams for this article were supplied by Paul W. Stevens, Rochester, N. Y., who has contributed articles on observing subjects to Sky and Telescope *many times in the past.*

The positions of the sun and moon at which the longest possible totality can occur.



NEWS NOTES

By Dorrit Hoffleit

LOST SATELLITE RECOVERED

Last observed in 1941, the eighth satellite of Jupiter has been rediscovered, thanks to UNIVAC, a Remington Rand high-speed electronic computer. Dr. Paul Herget, Cincinnati Observatory, was assisted by Dr. John Mauchly in calculating the positions of Jupiter VIII for every 10 days from 1940 to 1980, using starting values provided by Dr. Herbert Grosch. Actually, the positions for 10 slightly different orbits were computed, the machine accomplishing the entire task in about 2½ hours.

The predicted positions of the satellite were then sent to Dr. Seth B. Nicholson, of Mount Wilson and Palomar Observatories. He writes that in November and December, 1954, Jupiter VIII was too nearly in line with the planet to be photographed easily, but as soon as it was out of the glare near Jupiter, he photographed it with the 100-inch telescope. That was on January 25th, and the satellite was within one minute of arc of its predicted position for that date.

This 16th-magnitude object is so far from Jupiter—15 million miles on the average—that its motion undergoes very large and complex perturbations by the sun. Only with high-speed modern machines is it practicable to compute its ephemeris, so laborious are the computations required. Discovered at Greenwich in 1908 with a 30-inch reflector, Jupiter VIII has understandably been lost for long periods several times in the past. Dr. Herget reports that the new calculations should enable astronomers to keep track of this satellite at every opposition of the planet until 1980.

EXPANDING HYDROGEN REGIONS

In a paper before the American Physical Society, Dr. Malcolm P. Savedoff and John Greene, University of Rochester, discussed the effect of the expansion of the ionized hydrogen gas (H-II region) surrounding a newly formed hot star within a large uniform cloud of neutral hydrogen (H-I region).

Assuming initially equal densities in the two regions, and assuming their temperatures as 100° absolute in the H-I region and 10,000° absolute in the H-II region, the Rochester astronomers find that the pressure inside the H-II region is 200 times greater than it is outside. From this they deduce that there would be a rapid expansion of a shell of gas outward.

Separating the H-II and H-I regions, this shell of expanding material will be bounded on the outside by a shock wave and on the inside by an ionization front. The shell itself may be 200 times more dense than the undisturbed regions outside, and it would slowly increase in thickness while expanding at a speed of 14 kilometers per second. But as the less dense material of the ionized region would be providing the acceleration of the denser shell, the latter would be unstable and may be expected to break up into interstellar clouds. These could provide the material for the formation of protostars, which precede the actual existence of stars themselves.

The Rochester work was based on recent proposals by J. H. Oort and Lyman Spitzer, Jr., concerning the effect of intense radiation from hot stars on surrounding gases.

ORIGIN OF TEKTITES

Tektites are glassy objects found in about a dozen scattered large areas of the earth's surface, and have a chemical composition remarkably like that of clayey sediments. Their high melting points make terrestrial formation difficult to explain, and their origin has been the subject of much controversy. In a recent issue of the *Proceedings* of the National Academy of Sciences, Dr. Harold Urey, University of Chicago, reviews previous lunar and meteoritic hypotheses, and finds them all wanting on the basis of celestial mechanics or geochemical considerations. The tektites, he concludes, are to be regarded as terrestrial in origin.

Dr. Urey points out the probability that collisions between the earth and small asteroids have occurred since Miocene times. The energy of an asteroidal impact would be the equivalent of some hundred million atomic bombs, sufficient to volatilize 5,000 cubic kilometers of water or 2,000 cubic kilometers of rock. He asks, "Could such an object, falling in a land area, have initiated a large plutonic event which completely obliterated any characteristic cryptovolcanic effects? It does seem that such objects might be capable of producing large numbers of small glass objects from sedimentary materials and of distributing them over wide areas."

JESUIT ASTRONOMER DIES

Rev. Paul A. McNally, S.J., director of Georgetown Observatory from 1928 to 1948, died recently at the age of 64. Since 1950 he had been vice-president and dean of Georgetown University, District of Columbia, and regent and dean of its medical and dental schools.

Solar eclipses were the principal astronomical interest of Father McNally. He took part in eclipse expeditions in 1932 to Maine, in 1936 to Russia, 1937 to Canton Island, and to Brazil in 1940. His other astronomical activities concerned variable stars, nebulosities, occultations, and calendar reform.

IN THE CURRENT JOURNALS

THE GEOMETRY OF CRATER SHADOWS, by C. A. Cross, *Journal*, British Astronomical Association, January, 1955. "These methods [to find the three-dimensional shape of a crater from the outline of the shadow inside it] are applied to an examination of the shadows observed in 117 lunar craters. This discloses that sixty-one of the craters are indistinguishable from paraboloids of revolution, whilst thirty are ellipsoidal and twelve hyperboloidal. The remaining fourteen craters are not simple conoids of revolution."

COPERNICUS THROUGH THE MONTH, by Dinsmore Alter and Paul E. Roques, *Griffith Observer*, March, 1955. "The changes in its appearance, just as is true of the changes in the appearance of many other objects, are almost unbelievable to the man who is not used to telescopic observation of the moon."

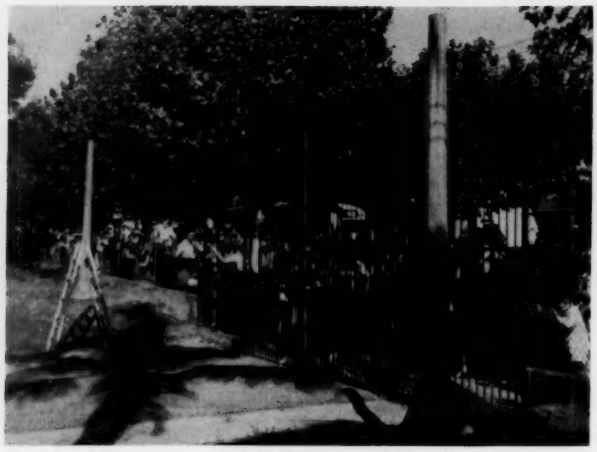
AEROMEDICAL AND BIOLOGICAL CONSIDERATIONS OF FLIGHT ABOVE THE ATMOSPHERE, by Col. Paul A. Campbell, *Journal*, British Interplanetary Society, January-February, 1955. "Generally speaking, the most serious problem relative to travel above the atmosphere is that of survival in case of accident. To date the solutions are not adequate, but experience has shown the pioneers of all forms of travel to be willing to consider high degrees of calculated risk as an acceptable occupational hazard."

RADIO TELESCOPES, by John D. Kraus, *Scientific American*, March, 1955. "The resolution of any telescope—optical or radio—is proportional to its aperture expressed in wavelengths. . . . To match the resolution of the Palomar Mountain telescope, with its 200-inch aperture, a radio antenna receiving at the one-meter wavelength would have to be as large as the diameter of the earth!"

CALTECH'S RADIO ASTRONOMY PROJECT

To supplement its work in optical astronomy at Mount Palomar, California Institute of Technology is initiating a radio astronomy project to be headed by John G. Bolton, the Australian pioneer in this field. Mr. Bolton was the discoverer of the first radio star (in 1948), and the first to identify a radio star with a visible object, the Crab nebula. He served for 10 years as a research scientist at Sydney in the division of radiophysics of the Commonwealth Scientific and Industrial Research Organization.

The major goals of the Caltech program will be to detect radio emission from outer space, to find out what its sources are, and to discover as much as possible about the position, strength, and size of these sources. Construction of new radio equipment is expected to start within a year.



These pictures by the author show, left, the entrance to the planetarium building, with policemen on duty; above, the crowds that lined up for lectures on the opening days. The attendance has continued heavy, requiring eight instrument demonstrations a week.

Montevideo Planetarium Inaugurated

NIGEL O'C. WOLFF, *Director, Montevideo Municipal Planetarium*

Staff members of the planetarium are, left to right: Sr. Guido, Sr. Scasso, the author, M. A. Varin, administrative director, E. J. Muttoni and H. Magnani, technicians, and J. A. Castelnuovo, director of public relations.

ON FEBRUARY 11th, the Municipal Planetarium of Montevideo, Uruguay, was opened before a group of 300 municipal and national officials.

The inaugural address that preceded the planetarium demonstration was delivered by Intendente (Mayor) Armando R. Malet, who spoke of the great cultural and educational significance of the opening of the first permanent planetarium in all of continental Latin America. Dr. Malet paid special tribute to former Intendente German A. Barbato, who began the project and had brought it to virtual completion before he left office in the late autumn of 1954.

Construction of the instrument was begun by Spitz Laboratories, Inc., in late 1951. The projector was described in an article in the July, 1954, *Sky and Telescope*, a few months after its delivery in South America, but before the building was completed.

The planetarium building was designed by architect Juan A. Scasso, who for many years has been director of Montevideo's huge system of public parks and recreation areas. It is several miles from the center of town, in the Montevideo Zoological Garden, a large section of which has been dedicated as a municipal center for the popularization of science.

In addition to the planetarium, plans for this center call for an aquarium, museums of physical science and natural history, a science library with a special children's section, a large auditorium, and a complete modernization of the park zoo.

The two-story planetarium building is topped by a structural concrete dome designed by Romeo Ottieri. The planetarium chamber is on the upper floor, has

a diameter of 60 feet, and seats an audience of 350. The projection dome is sheet steel, with 25 perforations, each 1/10 inch in diameter, per square inch. This steel surface is not suspended, for its base rests on the circular wall of the chamber.

The Model B Spitz planetarium hangs from steel cables which pass through the projection dome to anchor plates on the structural members of the concrete dome of the building.

On the lower floor of the building, directly below the planetarium room, there is a somewhat smaller circular chamber that is to serve as a hall of the solar system. It is hoped that this will eventually house a large mechanical orrery like that of the Hayden Planetarium in New York City. Surrounding the central chambers on both floors are wide passageways with room for exhibits. In addition to office and work space for the staff, there are a photographic darkroom, two small classrooms, and a workshop for Montevidean amateur telescope makers.

On the day following the inauguration, the planetarium was opened to the general public, with two demonstrations scheduled. Although a good attendance had been expected, the staff was surprised and nearly overwhelmed when more than 3,000 people showed up. It was immediately decided to have four shows instead of two on the following day, Sunday, but this proved to be far from adequate when more than 5,000 sought admission.

Since that time, the planetarium has been offering eight lectures a week, plus many demonstrations for special groups. The general introductory demonstration was continued until the end of March, with lecturing duties shared by me and Prof. Hector Fernandez Guido, chief of the technical staff of the planetarium. Our topic for April has been "A Trip from Pole to Pole."

The extreme enthusiasm Montevideo is showing for its new planetarium is overwhelming. From the great interest in science and culture in this city, I had anticipated success for the planetarium, but certainly not to the extent of needing squads of mounted police to control the crowds demanding admission! The public reaction proves that this newest planetarium must also be the most popular in the world.

Montevideo city officials at the inauguration, left to right: Jose D'Aiuto, president of the city council, Mayor Malet, Sr. Scasso, and Sr. Barbato.

Amateur Astronomers

FURTHER NEWS ABOUT THE SEATTLE CONVENTION

The Astronomical League convention on July 1-5 in Seattle, Wash., will open with registration on the morning of Friday, July 1st. Sessions will be on the University of Washington campus. Among speakers at the convention will be Dr. R. M. Petrie, director of the Dominion Astrophysical Observatory, Victoria, B. C., and Dr. T. S. Jacobsen, head of the department of astronomy at the University of Washington.

As announced in the January issue, page 103, accommodations are available on the campus, and reservations may be made directly with the Office of Short Courses and Conferences, 318 Administration Bldg., University of Washington, Seattle 5, Wash. A check for $5.20 ($5.70 after May 15th), payable to the University of Washington, will cover registration and approximately one day's room and meals for each individual.

There will be ample space for all types of exhibits. Material for display is to be registered with Guy R. Blackie, 18305 47th Ave. N. E., Seattle 55. Descriptive cards should accompany exhibits. Supporting members of the Astronomical League who wish to present commercial exhibits should also notify Mr. Blackie. There will be a guard on duty in the exhibit rooms during the convention.

Titles of papers are to be sent to Forrest Ritscher, 4727 16th Ave. N. E., Seattle 5. He needs to know the length of the talk, generally 10 or 15 minutes, the type of projection equipment required, and he should receive a copy of the paper as soon as possible.

A highlight of the convention program is a trip on July 4-5 by bus and ferry to Victoria and the Dominion Astrophysical Observatory. The cost will be about $10.00 plus lodging and food. The return trip will be via Vancouver, on the mainland of Canada. Applications for this trip should be made by May 15th, if possible, for there will be an extra charge of $2.50 after that date. Reservations for the trip and the lodgings in Victoria may be made by letter, with a deposit of $2.00, to Robert Nicola, 4231 E. 125th St., Seattle 55.

The visit to the observatory will be made on the evening of July 4th, and there will be observing through the 72-inch reflector if weather permits.

NORTH CENTRAL CONVENTION

The ninth annual convention of the North Central Region of the Astronomical League will be held in Chicago on Friday and Saturday, May 13-14, at the Adler Planetarium, 900 E. Achsah Bond Drive.

There will be registration and an informal gathering Friday evening. The main sessions will begin at 10 a.m. Saturday morning, and continue in the afternoon, featuring society reports and papers. The banquet will be at 7 p.m. at the North Park Hotel, 1931 Lincoln Park West. That evening, delegates have been invited by Dr. K. A. Strand to attend an open house at Dearborn Observatory in nearby Evanston. If weather permits, observing with the 18½-inch Clark refractor will be included.

Persons planning to attend the convention are asked to register as soon as possible, sending $1.00 registration fee to Mr. Russel McNiel, 2838 N. Albany Ave., Chicago 18, Ill. Anyone wishing to present a paper should notify the undersigned.

ROBERT G. JOHNSSON
Program chairman
7333 N. Ridge Ave.
Chicago 45, Ill.

SOUTHWEST REGION CONVENTION

On June 17-18, the Southwest Region of the Astronomical League will meet in the Fondren Science Building, Southern Methodist University, Dallas, Tex. Hosts are the Texas Astronomical Society and the Junior Texas Astronomical Society. The undersigned is convention chairman, to whom requests for further information should be addressed.

Registration will begin at 1:00 on the afternoon of Friday, June 17th, in Room 119, where all sessions of the convention will be held. Setting up of exhibits will begin at the same time in Room 109. The registration fee is $1.00 for adults, 50 cents for juniors under 18 years of age.

Seniors and juniors are requested to present papers on astronomical or related subjects. Copies of papers must be mailed to me not later than June 1st, in order to be included in the printed program.

Exhibits may be shipped to Dr. Frank C. McDonald, Fondren Science Building, Southern Methodist University, or brought by the exhibitor to Room 109. Frank C. Corlett, Jr., 2513 Catherine

St., Dallas, Tex., is exhibits chairman, and should be notified by all persons intending to exhibit.

E. M. BREWER
5218 Morningside Ave.
Dallas 6, Tex.

JUNIORS IN ARKANSAS

Our society, the Augusta Astronomy Club, is having its first anniversary on May 24th. We plan to celebrate on top of a large sand hill north of Augusta that is the highest point in Woodruff County. At this wonderful observing place, we have many all-night camps during the summer. We have been using my recently acquired 2.4-inch Unitron refractor.

We have nine members, ranging in age from nine to 14 years, and I am the oldest.

JOHN W. HARALSON
Augusta, Ark.

BELOIT SOCIETY CONDUCTS ROTARY CLUB PROGRAMS

Something a little different was attempted by us when the Beloit Rotarians were introduced to amateur astronomy at two recent meetings.

Dr. Ralph C. Huffer, professor of astronomy at Beloit College, spoke on March 8th concerning the importance of the amateur astronomer in astronomical research. Many instances were cited in which famous astronomers began their careers as amateurs. The activities of the Beloit Astronomical Society were outlined, including its exhibits at numerous local hobby shows.

A week later, the program was conducted by the undersigned, a past president of the society. A representative 6-inch reflector and a driving mechanism were demonstrated. Color slides were shown of club members using their telescopes, grinding a mirror, and working with other astronomical equipment. A number of general astronomical slides were shown to acquaint the layman with what an amateur sees through his completed instrument.

The Beloit society recommends this type of project for other amateur groups. You will be surprised how eager the service clubs are for such programs.

KENNETH E. PATTERSON
419 Pleasant St.
Beloit, Wis.

MICHIGAN SOCIETY ACTIVE

The Astronomical Society of Coloma, Mich., is now in its fifth year, and is incorporated. Although the membership is only 11, we have accomplished much. We have one small reflecting telescope, and are completing the Bronson Observatory to house a larger instrument, a darkroom, and a meeting room.

One of the members donated the land,

HERE AND THERE WITH AMATEURS

*Members receive *Sky and Telescope* as a privilege of membership. †Member organizations of the Astronomical League.

State	City	Organization	Time	Meeting Place	Communicate With
ALABAMA	Birmingham	*Shades Valley A.C.	7:30, 3rd Tue.	Homewood Pub. Libr.	John C. Heslip, 1500 Oxmoor Rd.
ARIZONA	Phoenix	*Phoenix Obs. Ass'n	8:00, 2nd, 4th Mon.	Phoenix Coll., homes	A. H. Hoff, 1102 W. Thomas Rd.
	Tucson	*Tucson A.A.	7:30, 1st Wed.	Steward Obs.	Mrs. Kathryn Burch, 216 Busch Pl.
ARKANSAS	Little Rock	†*Arkansas A.A.C.	7:30, 3rd Mon.	Fair Pk. Golf Club	C. P. Kulp, 1615 Fair Park Blvd.
CALIFORNIA	Bakersfield	Bakersfield A.A.	7:30, 1st Wed.	Private homes	Gary W. Schmidt, 1700 Quincy St.
	Fresno	*Central Val. Ast'mers	7:45, 2nd Mon.	Fresno Coll., homes	Elizabeth Dean, 3534 N. Callisch (3)
	Kentfield	*Marin Am. Ast.	8:00, 1st Mon.	Coll. of Marin	Rita Treleven, Box 102, Fairfax
	Long Beach	†*Excelsior Tel. Club	7:30, 3rd Fri.	Private homes	T. R. Cave, Jr., 265 Roswell Ave. (3)
	Los Angeles	L.A.A.S.	7:45, 2nd Tue.	Griffith Obs.	Miss H. Pearce, 1000 N. Seward, H'wood (38)
	Oakland	*Eastbay A.S.	8:00, 1st Sat.	Chabot Obs.	F. O. Groch, 2315 Eunice St., Berkeley (8)
	Palo Alto	*Peninsula A.S.	8:00, 1st Fri.	Community Center	H. W. Milner, 350 Tennyson Ave.
	Redlands	*Redlands A.S.	8:00, 4th Thu.	Univ. of Redlands	Miss R. Schweikert, 111 Prospect Dr.
	Sacramento	*Sac. Val. A.S.	8:00, 2nd Thu.	Calif. Jr. Mus.	Mrs. E. Champ, 3816 Sacramento Blvd. (17)
	San Diego	Ast. Soc. of S.D.	7:30, 1st Wed.	504 Electric Bldg.	W. T. Skilling, 3140 Sixth Ave.
	San Diego	A.T.M. Ast. Club	7:30, 2nd, 4th Mon.	3121 Hawthorn St.	Al Nelson, 3121 Hawthorn St.
	San Francisco	*S.F. Am. Ast'mers	8:00, 1st Wed.	Randall Jr. Museum	H. A. Wallace, 2925-A Jackson St.
	Stockton	*Stockton A.S.	8:00, 2nd Mon.	Stockton Coll., C-3	W. D. Purdy, 325 E. Kettleman Lane, Lodi
	Whittier	Whittier A.S.	7:00, Alt. Sun.	Private homes	Gary A. McCue, 7855 S. Euclid Ave.
COLORADO	Boulder	*Boulder A.S.	7:30, 2nd Wed.	Sommers-Bausch Obs.	Vernon Goerke, 3045 Bluff St., HI 2-3447
	Denver	*Denver A.S.	8:00, 2nd, 4th Fri.	Chamberlin Obs.	Ralph Asbury, 340 Cherokee, SP 7-2012
	Pueblo	†*Pueblo A.S.	7:30, 1st Mon.	2421 2nd Ave.	Mrs. Marjorie Struthers, 2329 E. Routt Ave.
CONNECTICUT	Middletown	†*Central Conn. A.A.	8:00, 1st Tue.	Van Vleck Obs.	W. Fellows, RFD No. 1, Hill St., Glastonbury
	New Haven	†A.S. of New Haven	8:00, 4th Sat.	Sterling Tower	Florence Welter, 77 Spring Rd., N'th Haven
	So. Norwalk	†Fairfield Co. A.S.	8:00, 3rd Fri.	Stamford Museum	Goldie L. Grantham, 58 Bouton St.
DIST. COL.	Washington	†*Nat'l. Cap. Ast'mers	8:00, 1st Sat.	Comm. Dept. Audit.	Miss E. Goerner, 20 Plattsburg Ct. N.W. (16)
FLORIDA	Daytona Beach	D. B. Stargazers	8:00, Alt. Mon.	105 N. Halifax Ave.	Wm. T. Thomas, 105 N. Halifax
	Jacksonville	†*J.A.A.C.	8:30, 1st, 3rd Mon.	Private homes	E. L. Rowland, Jr., 225 W. Ashley St. (2)
	Key West	†Key West A.C.	8:00, 3rd Thu.	Private homes	J. M. Martin, 1605 United St.
	Miami	†*South'n Cross A.S.	8:15, 3rd Mon.	Central School	A. P. Smith, Jr., 426 S. W. 26 Rd.
	Miami Springs	†*Gulfstream A.A.	8:00, 4th Wed.	400 SW 2nd Ave., Miami	L. G. Pardue, 641 Falcon, 88-5434
	Orlando	*A.A.C. of Orlando	7:30, 2nd Thu.	Edgewater H.S.	Claude B. Green, 354 Mashie Lane
	Patrick AFB	*Banana River A.S.	8:00, 2nd Wed.	PIO, Bldg. T-580	Helen DePaolo, 1353 Everglade Dr., Eau Gallie
	Pensacola	†Pensacola A.A.C.	8:00, Wed.	Private homes	John Aguilar, 1203 N. 9 Ave.
	St. Petersburg	†St. P'burg A.A.C.	7:30, 4th Tue.	City Museum Audit.	Dr. R. E. Angell, 233 5th Ave. N.
GEORGIA	Atlanta	†*Atlanta A.C.	8:00, 3rd Fri.	Agnes Scott College	W. H. Close, 225 Forkner Dr., Decatur
	Columbus	*Columbus A.A.C.	7:30, 2nd Fri.	Bradley Mem. Lib.	Mrs. J. Jones, 2605 Cherokee Ave.
HAWAII	Honolulu	Hawaii A.S.	7:30, 3rd Tue.	McKinley H.S., Cot. 36	R. Terry, 99-531 Kaholi Pl., Aiea, 463762
IDAHO	Idaho Falls	Idaho A.A.	8:00, 1st Sat.	475 J St.	Mrs. O. W. Hendrickson, 475 J St.
ILLINOIS	Chicago	†*Burnham A.S.	3:00, 2nd Sun.	Adler Planetarium	J. A. Anderer, 7929 S. Loomis Blvd. (20)
	Galesburg	†*G'burg Am. Ast'mers	7:30, 1st Wed.	Knox Obs.	Harlowe L. Horein, 1246 N. Morton Ave.
	Geneva	*Fox Valley A.S.	8:00, 2nd Tue.	Geneva City Hall	Joseph Zoda, 420 Fellows St., St. Charles
	Moline	†*Popular A.C.	7:30, Wed.	Sky Ridge Obs.	Carl H. Gamble, 3201 Coaltown Rd.
	Peoria	Ast. Sec., Acad. Sci.	8:00, 1st Wed.	Glen Oak Pk. Pav'n.	R. P. Van Zandt, 156 N. Eleanor Pl. (5)
INDIANA	Indianapolis	†*Indiana A.S.	2:15, 1st Sun.	Riley Library	W. E. Wilkins, 6124 Dewey Ave. (19), IR-5946
	South Bend	*St. Jos. Valley Ast.	7:30, 1st Thu.	YMCA	Bruce A. Lovell, RR 6, Box 61A
KANSAS	Wichita	†*Wichita A.S.	8:00, 1st Wed.	Friends Univ.	S. S. Whitehead, 425 N. Lorraine (8), 62-6642
KENTUCKY	Louisville	†L'ville A.S.	8:00, 1st Tue.	Univ. of Louisville	B. F. Kubaugh, 207 Sage Rd. (7)
	Louisville	†*L'ville Jr. A.S.	7:30, 3rd Tue.	Private homes	Carol Lipphard, 2421 Calvin Ave. (6)
LOUISIANA	Gretna	Gretna A.S.	7:00, 2nd, 4th Sat.	209 Newton St.	John A. Gunther, 209 Newton St., Algiers 2710
	Lake Charles	†*Lake Charles A.A.C.	7:45, 2nd Tue.	H.S. Chem. Lab.	Norman G. Lore, 532 Alamo St.
	New Orleans	A.S. of N.O.	Irregular	Cunningham Obs.	Dr. J. Adair Lyon, 1210 Broadway
MASSACHUSETTS	Cambridge	†*Bond A.C.	8:00, 1st Thu.	Harvard Obs.	R. Smith, 519 Quincy Shore Dr., No. Quincy 71
	Cambridge	†*A.T.M.s of Boston	8:00, 2nd Thu.	Harvard Obs.	W. Knight, 75 S. Crescent Cir., Brighton 35
	Springfield	†*S'field Stars	8:00, 2nd Wed.	Private homes	J. Welch, 107 Low'r B'verly Hills, W. S'field
	Worcester	†*Aldrich A.S.	7:30, 1st, 3rd Tue.	Mus. Natural Hist.	W. C. Lovell, 24 Courtland (2), 3-1559
MICHIGAN	Battle Creek	†B. C. A.A.C.	8:00, 2nd Fri.	Kingman Museum	Mrs. W. V. Eichenlaub, 47 Everett Ave.
	Detroit	†*Detroit A.S.	2:30, 2nd Sun.	Wayne U., State Hall	E. R. Phelps, Wayne University
	Jackson	*Jackson A.S.	7:30, 2nd Thu.	Public Library	Allen Bell, 1103 Hamlin Pl.
	Kalamazoo	†Kalamazoo A.A.A.	8:00, Sat.	Private homes	Edgar Pashby, 420 Evelyn Ave.
	Lansing	†*Lansing A.A.	8:00, Sat.	Private homes	R. Elliott, 434 Cowley Ave., E. Lansing
	Pontiac	†*Pon.-N.W. Det. A.A.	7:30, 3rd Thu.	Lincoln Jr. H.S.	G. Carhart, 40 Hadsell Dr., FE 2-9980
MINNESOTA	Minneapolis	*J.A.C. of M'polis	4:15, 2nd, 4th Wed.	Public Library	E. Haskins, 3732 Garfield Ave. S., RE-0201
	Minneapolis	M'polis A.C.	7:30, 1st Wed.	Public Library	Maxine Begin, Sci. Mus., M'polis Pub. Lib.
	St. Paul	†*St. Paul Tel. Club	7:30, 2nd, 4th Wed.	Macalester Coll.	John Fleischhacker, 3520 Edgerton St. (6)
MISSOURI	Fayette	†*Central Mo. A.A.	7:30, 3rd Sat.	Morrison Obs.	R. C. Maag, 816½ S. Mass., Sedalia
	Kansas City	†*A.C. of Kans. City	8:00, 4th Sat.	K.C. Museum	Mrs. Laura Kinsey, 4604 Jefferson (12)
	St. Louis	†*St. Louis A.A.S.	8:00, 3rd Fri.	Inst. of Tech., St. L. U.	Mrs. N. Fallert, 1509 N. Berry Rd., Rock Hill (19)

and several large trees that members cut and sawed into lumber. We cleared the land, poured the concrete foundation and floor, and did all the construction on the building. Now we are raising funds for completing the building and for the new telescope.

ROBERT L. PUMFERY, president
Astronomical Society of Coloma
Coloma, Mich.

THIS MONTH'S MEETINGS

Cambridge, Mass.: Bond Astronomical Club, 8 p.m., Harvard Observatory. May 5, Dr. Dorrit Hoffleit, Harvard Observatory, "High-Altitude Balloons."

Chicago, Ill.: Burnham Astronomical Society, 3 p.m., Adler Planetarium. May 8, John Sternig, "Can There Be Life on Other Worlds?"

Cleveland, Ohio: Cleveland Astronomical Society, 8 p.m., Warner and Swasey Observatory. May 13, Dr. Bart J. Bok, Harvard Observatory, "Our Stellar System."

Dallas, Tex.: Texas Astronomical Society. May 23, 8 p.m., field meet, home of John M. Hulme, 3722 Manana St.

Geneva, Ill.: Fox Valley Astronomical Society. May 22, annual picnic, Wheeler Memorial Park.

Kalamazoo, Mich.: Kalamazoo Amateur Astronomical Association, 8 p.m., home of Dr. Durey Peterson, 4615 Grand Prairie Ave. May 21, William Persons, "The Calendar."

Long Beach, Calif.: Excelsior Telescope Club, 8 p.m., home of Dick Norton, 3157 Chatwin Ave., Lakewood Village. May 20, Frank Daley, "How to Figure a Refractor Objective."

Minneapolis, Minn.: Minneapolis Astronomy Club. May 4, annual picnic, 6 p.m., Glenwood Park.

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. May 18, annual meeting.

Rutherford, N. J.: Rutherford Astronomical Society, 8:15 p.m., YMCA. May 5, Paul Slate, "Asteroids"; Paul Hagar, "New Hypotheses."

St. Louis, Mo.: St. Louis Amateur Astronomical Society, 8 p.m., St. Louis Institute of Technology. May 20, Dr. George Bulger, Washington University, "Kuiper's Lunar Theory."

South Bend, Ind.: St. Joseph Valley Astronomers, 7:30 p.m., YMCA. May 5, Richard Foltz, "Precession of the Equinoxes."

Washington, D. C.: National Capital Astronomers, 8:15 p.m., Commerce Department auditorium. May 7, Dr. Maurice Shapiro, Naval Research Laboratory, "Cosmic Rays."

HERE AND THERE WITH AMATEURS *(continued)*

State	City	Organization	Time	Meeting Place	Communicate With
NEVADA	Reno	A.S. of Nev.	8:00, 4th Thu.	Univ. of Nevada	Dr. Vernon Frazier, University of Nevada
NEW JERSEY	Caldwell	West Essex A.S.	8:30, 2nd Mon.	Caldwell Mun. Bldg.	Donald C. Smith, 19 Francisco Ave.
	Cranford	†*A.A.S. of Union Co.	8:00, 4th Fri.	Plainfield YWCA	Mrs. W. N. Lurcott, 220 High St.
	Rutherford	A.S. of Rutherford	8:00, 1st Thu.	YMCA	Mrs. Helen Waite, 11 Bryan Ct.
	Teaneck	†Bergen Co. A.S.	8:30, 2nd Wed.	Obs., H.S. grounds	C. Milos, 631 Ridgewood Rd., Oradell
NEW MEXICO	Las Cruces	†*A.S. of L.C.	7:30, 1st or 2nd Sat.	Private homes	W. H. Haas, 1203 N. Alameda Blvd.
	Roswell	*Pecos Val. S.&T.C.	7:30, 2nd Fri.	Cham. of Comm.	Dr. R. R. Boice, Rt. 2, Box 163A
NEW YORK	Brooklyn	†Junior A.C.	8:00, 3rd Fri.	B'klyn Public Library	Jr. A. C., Pub. Lib., Grand Army Plaza (38)
	Buffalo	†*Buffalo A.A.	7:30, 1st Wed.	Mus. of Science	Dr. F. S. Jones, 83 Briarcliffe, Cheektowaga (25)
	Corning	Corning A.C.	8:00, 1st, 3rd Mon.	Corning Glass Center	W. R. Redmond, 3 E. 3rd St.
	Gloversville	†A.C. of Fulton Co.	6:30, Wed.	Private homes	Emmanuel Weil, 38 E. Blvd.
	New York	*A.A.A.	8:00, 1st Wed.	Amer. Mus. Nat. Hist.	G. V. Plachy, 201 W. 79th (24), EN 2-7100
	Rochester	†Ast. Sec., Acad. Sci.	8:00, 1st Fri.	Rochester Museum	Louise M. Zeitler, 91 Hickory St. (20)
	Schenectady	†*S'tady A.C.	7:30, 3rd Mon.	Union Coll., C.E. Bldg.	C. E. Johnson, 102 State St.
	Troy	†*Renss. Ap. Soc.	8:00, Fri.	R.P.I. Obs.	Dr. Robert Fleischer, R.P.I.
	Troy	*Troy A.C.	8:00, 4th Sat.	Private homes	P. Cenni, 2316 6th Ave.
	Utica	†*Utica Am. Ast'mers	7:30, 4th Tue.	Proctor Inst.	S. Wolczanski, 506 William St.
	Wantagh	Long Island A.S.	8:00, Sat.	Private homes	A. R. Luechinger, 2009 Seaford Ave., 1571
N. CAROLINA	Chapel Hill	†Chapel Hill A.C.	8:00, Alt. Wed.	Morehead Plan.	C. C. Tucker, Jr., Morehead Planetarium
	Charlotte	*Charlotte A.A.C.	8:00, Last Mon.	Myers Pk. H.S.	Mrs. L. W. Kelly, 1014 Kennilworth Ave. (3)
	Greensboro	†*Greensboro A.C.	8:00, Fri.	Woman's Coll., U.N.C.	Dr. A. D. Shaftesbury, 315 Tate St.
	Winston-Salem	†*Forsyth A.S.	7:30, Last Fri.	Private homes	Kenneth Shepherd, 1339 W. 4th St.
NORTH DAKOTA	Grand Forks	†*Red River A.C.	8:00, 2nd, 4th Mon.	City Hall	L. G. Peck, 2101 1st Ave. North
OHIO	Akron	*A.C. of Akron	8:00, Last Fri.	YMCA	Mrs. R. J. Couts, 878 Kennebec Ave. (5)
	Cincinnati	*Cin. A.A.	8:00, Various days	Cincinnati Obs.	John G. Weigel, 2481 Erie Ave. (8)
	Cincinnati	*Cin. A.S.	8:00, 3rd Fri.	Obs., Zion Rd., M. Hts.	Isolina Cartlidge, 5556 Raceview Ave. (11)
	Cleveland	Cleveland A.S.	8:00, Fri.	Warner & Swasey Obs.	Mrs. Helen Strohm, Warner & Swasey Obs.
	Columbus	*Columbus A.S.	8:00, 2nd Sat.	McMillin Obs.	Miss R. A. Charlton, 1361 E. 22 Ave. (11)
	Dayton	A.T.M.s of Dayton	Eve., 3rd Sat.	Private homes	F. E. Sutter, 5038 Lebanon Pike (9)
	Lorain-Elyria	*Black River A.S.	8:00, 1st Wed.	Ely School	Leonard Sipple, Box 231
	Marietta	Marietta A.S.	Irregular	Cisler Terrace	Miss L. E. Cisler, Cisler Terrace
	Toledo	Toledo Ast. Club	...., 3rd Tue.	Univ. of Toledo Obs.	E. D. Edenburn, 4124 Commonwealth Ave.
	Warren	Mahoning Val. A.S.	8:00, Fri.	Private homes	C. R. Prather, 1363 Drexel, NW, 4494-2
	Youngstown	*Y'town A.C.	7:30, 1st Fri.	Homestead Pk. Pav'n.	F. W. Hartenstein, 907 Brentwood
OKLAHOMA	Tulsa	†*Tulsa A.S.	7:30, 1st Sat.	Private homes	J. C. Wells, 524 S. 78th E. Ave.
OREGON	Portland	†*Portland A.S.	7:30, 1st Tue.	Central Public Lib.	Mrs. Marge Krutsinger, 6525 NE Davis St. (16)
	Portland	†A.T.M. & Observers	8:00, 2nd Tue.	Private homes	Mrs. Marge Krutsinger, 6525 NE Davis St. (16)
PENNSYLVANIA	Beaver	†*Beaver Co. A.A.A.	8:00, 2nd Tue.	Private homes	Mrs. R. T. LuCaric, Brownsdale Plan, Baden
	Harrisburg	A.S. of Harrisburg	8:00, 1st Mon.	State Museum	Edward J. Naylor, 320 Wilhelm Rd.
	Millvale	A.A.A. Shaler T'ship	8:00, 1st Fri.	Cherry City Fire House	Cliff Raible, 200 Rebecca Sq. (9)
	Philadelphia	†A.A. of F.I.	8:00, 3rd Fri.	Franklin Institute	Edwin F. Bailey, LO 4-3600
	Philadelphia	†*Rittenhouse A.S.	8:00, Fri.	Franklin Institute	John W. Streeter, LO 4-3600
	Pittsburgh	†*A.A.A. of P'burgh	8:00, 2nd Fri.	Buhl Planetarium	Mary Burcik, 315 Moore Ave. (10)
	Pottstown	†Pottstown A.A.C.	7:30, Fri.	Public Library	W. E. Schultz, Public Library
RHODE ISLAND	N. Scituate	Skyscrapers, Inc.	8:00, Mon. or Wed.	Seagrave Mem. Obs.	Seagrave Mem. Obs., Box 157
TENNESSEE	Chattanooga	†*Barnard A.S.	8:00, 3rd Fri.	Jones Observatory	A. H. Jones, 411 W. 21st St., 5-1646
	Memphis	†Memphis A.S.	7:30, 1st, 3rd Fri.	Private homes	J. M. Buhler, 3796 Central Ave.
	Nashville	*Barnard A.S.	8:00, 2nd Thu.	Dyer Observatory	Miss C. Kidd, Dyer Obs., Vanderbilt U.
TEXAS	Abilene	*Abilene A.S.	7:30, 4th Mon.	Phys. Rm., H.-S.U.	T. D. Roberts, Hardin-Simmons Univ.
	Austin	*Forty Acres A.C.	7:30, 1st Tue.	U. of Tex., Physics Bldg.	Forty Acres A.C., Box 7994, Univ. Sta.
	Brownfield	*Brownfield A.C.	8:00, 3rd Wed.	Private homes	Charles W. Isbell, Brownfield 2074
	Dallas	†Texas A.S.	8:00, 4th Mon.	Various auditoriums	E. M. Brewer, 5218 Morningside, UN-3894
	Ft. Worth	†*Ft. Worth A.S.	8:00, 4th Thu.	Children's Museum	James M. McMillen, 604 Tierney Rd. (3)
	Laredo	*Laredo A.C.	8:00, 2nd Tue.	Laredo Jr. Coll.	Sidney Freidin, Box 1148
	Port Arthur	†*Port Arthur A.C.	7:30, 2nd Thu.	5228 Fifth St.	F. T. Newton, 5213 Fifth St., 2-4807
UTAH	Salt Lake City	*A.S. of Utah	8:00, 2nd Fri.	City and County Bldg.	James W. Geertsen, 4461 S. 9th East St.
VIRGINIA	Harrisonburg	Astral Society	Monthly	Vesper Heights Obs.	M. T. Brackbill, Eastern Mennonite College
	Norfolk	†*Norfolk A.S.	8:00, 2nd Thu.	Museum of Arts	A. Hustead, U.S. Weather Bureau, LO 3-4368
	Richmond	†*Richmond A.S.	8:00, 1st Tue.	601 E. Franklin St.	B. S. Ragland, 601 E. Franklin St. (19)
	Roanoke	*Am. Ast'mers of Roa.	...., 2nd Fri.	YMCA	Mrs. K. Burke, 11 Mountain Ave. SE 3-2359
WASHINGTON	Seattle	†*Seattle A.A.S.	8:00, 2nd Wed.	Eagle'n Hall, 1417 E. 42	Norman Dalke, 3640 Densmore Ave.
	Spokane	†*A.T.M.s of Spokane	8:00, Last Fri.	Private homes	Mrs. E. Mortensen, W. 1519 Augusta Ave.
	Tacoma	†Tacoma A.A.	8:00, 1st Mon.	Coll. of Puget Sd.	Mrs. Roy Atkinson, 2816 N. Union Ave.
	Yakima	†*Yak. Am. Ast'mers	8:00, 2nd Mon.	Cascade Creamery	Edward J. Newman, 324 W. Yakima Ave.
WEST VIRGINIA	Fairmont	†Fairmont A.A.A.	7:30, 2nd Fri.	State Coll., Sci. Hall	David Meisel, 800 8th St.
WISCONSIN	Beloit	†*Beloit A.S.	7:30, 2nd, 4th Wed.	YMCA Bldg.	K. E. Patterson, 318 Public Service Bldg.
	Madison	†Madison A.S.	8:00, 2nd Wed.	Washburn Obs.	Dr. C. M. Huffer, Washburn Obs.
	Milwaukee	†*Milw. A.S.	7:45, 3rd Fri.	Finney Branch Lib.	E. A. Halbach, 2971 S. 52 St. (15)
	Sheboygan	*Sheboygan A.S.	7:30, 2nd Tue.	Mead Public Lib.	T. Kruschke, 2016 N. 8th St.

Good Observing Days Are Here Again

With them we have a new service to offer in slide set 5 of the June 30, 1954, solar eclipse. Some slides are nearly alike but the collection is a fine summary of what different instruments will do for you in the field of photography. A good supplement to these slides is the data in the September, 1954, issue of *Sky and Telescope*. We have already had very favorable comments from early purchasers.

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Sponsored by the
Teachers' Committee of the American Astronomical Society

TEACHING EQUIPMENT FOR INTRODUCTORY COURSES

THE AVAILABILITY of apparatus for laboratory work and instruction in introductory college astronomy courses is a serious problem for new teaching departments and for others whose existing equipment is wearing out. In addition, there are many amateur groups and classes that would like to know how such material as orreries and celestial globes suitable for laboratory use can be obtained.

The foregoing problem has had the attention of the Teachers' Committee for many years, and at the 1953 Nashville meeting of the American Astronomical Society I was asked to look into the matter further. Dr. Freeman Miller has made available to me the results of a questionnaire sent to colleges in 1950; his report should eventually be published in its entirety, for it contains much valuable information, although the details of its picture now appear to need some modification.

During the 1920's and 1930's, the Eastern Science Supply Company, Boston, Mass., was almost the only source of strictly astronomical items for classroom and laboratory. We all benefited by the wholehearted co-operation of its owner, H. W. Geromanos, with teacher designers like John C. Duncan and Harlan T. Stetson. By 1940, however, Mr. Geromanos had to reduce his services to teachers, because of the pressure of defense work, and perhaps because of a temporary saturation of the never-large market in astronomical instructional goods.

Plans to improve this situation were made both during and after the war, but without success. In 1946 the Teachers' Committee was prepared to receive orders for Eastern Science Supply Company, but the scheme proved too cumbersome, and lapsed.

The 1950 questionnaire asked about useful equipment locally built, and also about needed equipment not then commercially available in satisfactory form. These latter questions were based on the original Eastern Science list of products. Replies were received from 200 institutions. Each of the following items was indicated as needed by some 50 or more colleges: celestial globes, Kirchhoff's spectrum-law apparatus, orreries, Foucault pendulums, precession demonstrators, scale models of planets and typical stars, student theodolites, and wall charts. A college department would require only one of each of the above, except for charts, globes, and perhaps theodolites and the spectrum apparatus.

From the answers to the questionnaire, the rough dimensions of the problem began to emerge, indicating that some of us (the teachers of astronomy) have occasionally been perfectionistic in our thinking about apparatus and unrealistic about its cost.

Special attention should be given to celestial globes, of which about 100 appeared to be needed in 1950. It is fair to say that practically everyone who has used the "Duncan globes" regards them as far superior for teaching purposes to any others that have been available. Their excellence lies in the good printing on the ball, the sturdiness of the mounting, and the clarity of its markings.

While the copper plates from which Rand McNally printed the paper gores for these globes were melted down during the war, Dr. Duncan has indicated to me his willingness to co-operate on a new set of plates, but manufacturing these might prove very costly. The last two mountings Mr. Geromanos assembled were bought by Ohio Wesleyan two years ago, but the tools and jigs for the mountings are in existence, and are being sent to me. New mountings can be produced in any number required, and I believe that some globe maker, such as Rand McNally or Denoyer-Geppert, could make satisfactory light-background balls from other plates, thereby avoiding the cost of new plates.

About two years ago, Ohio Wesleyan purchased the entire remaining stock of Eastern Science lantern slides, including the negatives. As part of the arrangement, we undertook to supply slides from the Eastern Science catalogue list to those requesting them.

At present, most of Mr. Geromanos' material is disassembled and lacks much of the proper optics. Probably four to a dozen units of most items could be made up, except for globes, precession demonstrators, and coelospheres, and for some items the jigs are available. The last orrery and spare parts have already been sold.

Could not a private college purchase the entire above stock, finish the needed units, and manufacture other items on a no-profit, no-loss basis, aided by a grant from some foundation? I am already exploring a possible local arrangement of this sort. The need for such teaching equipment has everywhere become so critical that we must break the vicious circle caused by small budgets, high cost of design and tooling, and the small market. The plan suggested here would not solve the whole problem, but would be a major step forward.

JOHN E. MERRILL
Ohio Wesleyan University

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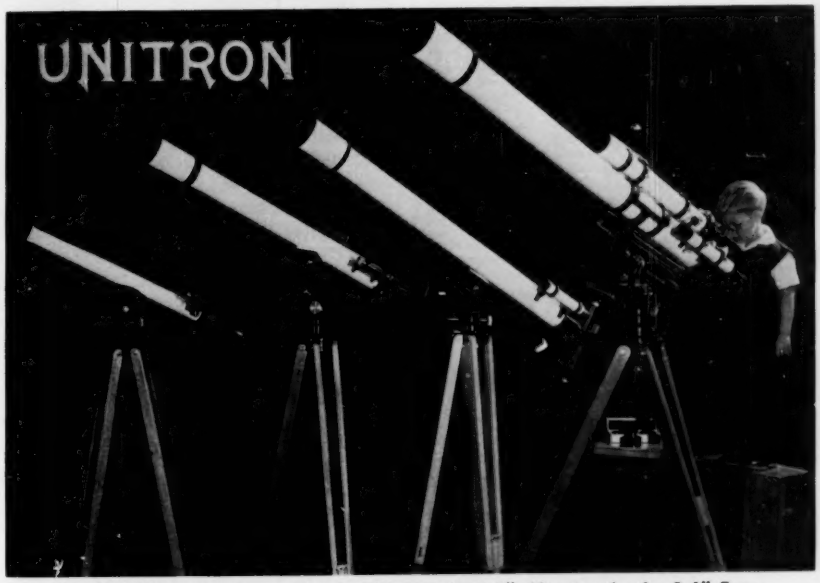

The UNITRON Refractors, left to right, are the 1.6" Altazimuth, the 2.4" Equatorial, the 3" Altazimuth, the 4" Photo-Equatorial, with a young observer.

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(See page 308 and the back cover)

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BOOKS AND THE SKY

FIELD BOOK OF THE SKIES

William T. Olcott, revised and edited by R. Newton Mayall and Margaret W. Mayall. G. P. Putnam's Sons, New York, 4th edition, 1954. 482 pages. $5.00.

THE charm of earlier editions of the *Field Book of the Skies,* which has attracted so many amateur astronomers, both beginning and advanced, lies in the variety of aspects from which astronomy is presented. The latest revision, by the recorder of the American Association of Variable Star Observers and her husband, maintains this arrangement.

The reader of this handbook is invited to contemplate the constellations one by one, as they come into view with the changes in the seasons. There are two charts for each star group, one for the naked-eye or field-glass observer, the other for the user of a small telescope. With each chart are appropriate descriptions, including constellation mythology that affords a glimpse into the pageantry of the past.

As for first and last things, the opening sections of the book pave the way for our voyage with an introduction to the all-important fundamentals of astronomy, while the appendixes provide a haven for lovers of facts and figures. The tables are replete with data concerning the solar system, interesting stars, clusters, and nebulae. Unlike the main body of the work, in some parts the appendixes are not limited to the sky as seen chiefly from latitude 40° north.

After the constellation charts, the moon, sun, planets, comets, meteors, and eclipses are presented from an observational point of view. Then small telescopes are discussed, and many hints on their proper use are listed. In the chronological table of astronomical history, the heroes of astronomy parade before us with tokens of their discoveries.

The section on star names and their meanings depends on Allen's book of 1899, but some notice of later work on the subject might have been appropriate.

The new list of Messier objects, with their magnitudes, is noteworthy. At last, NGC numbers have been supplied for clusters and nebulae. The chronology has been extended to 1954, and there is a new list of publications. The separate indexes are now combined into one, to the reader's convenience.

A valuable innovation is the six-figure designation of each double star, based on its location. These numbers are on the same system as the variable star designations used by the AAVSO. The position angles for double stars have been omitted. In former editions these were given without the dates of the measurements, and thus were sometimes misleading.

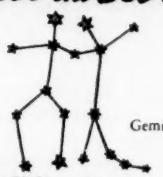
In a book containing so much information, some errors and misprints may be expected, not all of which can be mentioned here. As instances we may note, on page 55 "Piazzi Smyth" should be "Piazzi"; on page 64 the year Riccioli found Mizar to be a double star should be 1650 and not 1850. The statement on page 120 that Alpha Crateris is common to the constellation of Hydra and Crater is no longer true, in view of the revision of constellation boundaries by the International Astronomical Union.

On page 256, it is stated that Alpha Arietis is one of the stars from which longitude is measured, but this has not been true since the last century, when navigators stopped using the method of lunar distances to find their geographic longitude. There are some misprints, as "Acherna" for "Achernar" (page 300), and "Chaldni" for "Chladni" (page 376).

In the chronological table, page 408 has "Stower" in place of "W. Struve," and on the next page the date of the return of Halley's comet should read 1835 and not 1854. On page 411, Eros is incorrectly described as "the nearest asteroid"; several other asteroids have been found that can come closer to the earth.

Among the omissions are the celestial photographs that were so alluring to the beginner—there is not a halftone engrav-

Meet the Twins



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ing in the book, although the dust jacket says, "with charts, photographs and special diagrams."

But the improvements that have been made far overshadow these slips. The constellation diagrams and seasonal star maps have been redrawn from the originals, and earlier ambiguities and omissions corrected. I remember the bad night an older edition gave me when, as a beginner, I sought to locate the star cluster M38 in Auriga. The appendix has been vastly improved, and many revisions made in the double star data.

Owning this book, the amateur is indeed ready to explore the vast and varied architecture of the universe.

P. V. RIZZO
Amateur Astronomers Association
New York City

ERFORSCHUNG DER STRUKTUR UND ENTWICKLUNG DER STERNSYSTEME

B. W. Kukarkin. Akademie Verlag, Mohrenstr. 39, Berlin W8, 1954. 133 pages. DM 18.

IF YOU were to meet a friend whom you had not seen for years, dressed in new clothes and displaying ostentatious manners, you would think at first that he was another person. But soon you would realize that he was still the "same old fellow."

Such is our experience with the book under review. The slender, neatly bound German volume, elegantly printed on excellent paper, is in strong contrast to the first work in Russian, a paper-bound book that appeared in 1949. This writer published a short review in *Popular Astronomy*, May, 1950.

The content of the book falls in two parts. The first three chapters concern the study of our galaxy by means of the intrinsic variable stars—the main theme of the book. A final chapter is dedicated to a very general discussion of the structure and development of stellar systems.

Kukarkin follows exactly the classification of variable stars defined by Mrs. Gaposchkin and myself in 1938. He then proceeds to connect the various physical properties of the intrinsic variables with their locations in space and their motions.

The chef-d'oeuvre of the book is the pair of chapters in which the properties of RR Lyrae stars and classical Cepheids are thoroughly discussed. Their physical characteristics are adroitly related to the great pattern of our galaxy. Kukarkin emphasizes that the galaxy consists of several subsystems of stars; they may exist side by side, or be dovetailed together, or mingled in a disorderly fashion. Population I and Population II, as used by us, are extreme examples of such subsystems; the Russians consider these terms ill-chosen, and prefer the designations "very flat" and "spherical."

As the author reaches the climax of his discussion, we see how the seemingly humble and unimportant work of the variable star observer leads us to an understanding of the structure and development of the galaxy. The most important single result of this study is that the sun is $7{,}250 \pm 175$ parsecs from the galactic center.

In the more speculative second part of the book, Kukarkin seeks to identify old and young stars. His old stars include a long series of subdwarfs, which he carries up to meet a horizontal sequence of giants at class *B*0 and absolute magnitude zero; this horizontal sequence forks at about class *G*6. His young stars include the ordinary main sequence, a giant-supergiant branch from *F*5 to later classes, and a subgiant branch for the same classes.

In this new edition and translation, there are many additions and changes to the original Russian text, the result of the swiftly rising tide of research on variable stars all over the world. The literary references are complete up to 1952, and one is dated 1954. But Kukarkin has elided the great changes that have come over the study of Cepheids during the past three years. If he had not done so, he would have been forced to rewrite the book.

Although the translation, by Fritz Bartels, is excellent, he has made a few mistakes. Through slips in transliteration, he consistently writes W Leonis for W Virginis; the star BH Serpentis is incorrectly called WN Serpentis.

Astronomical readers who do not know Russian will welcome the German translation of Kukarkin's book. They must be prepared, however, for the childish fury of the author against the "idealistic" Western astronomers, among whom he singles out Jeans for special criticism. Kukarkin is fighting windmills; the men he criticizes are as materialistic as he is. Moreover, readers must endure the obvious bias in favor of Soviet astronomy and the disparaging attitude toward all work done in the Western Hemisphere (on which, however, the author has not been unwilling to draw).

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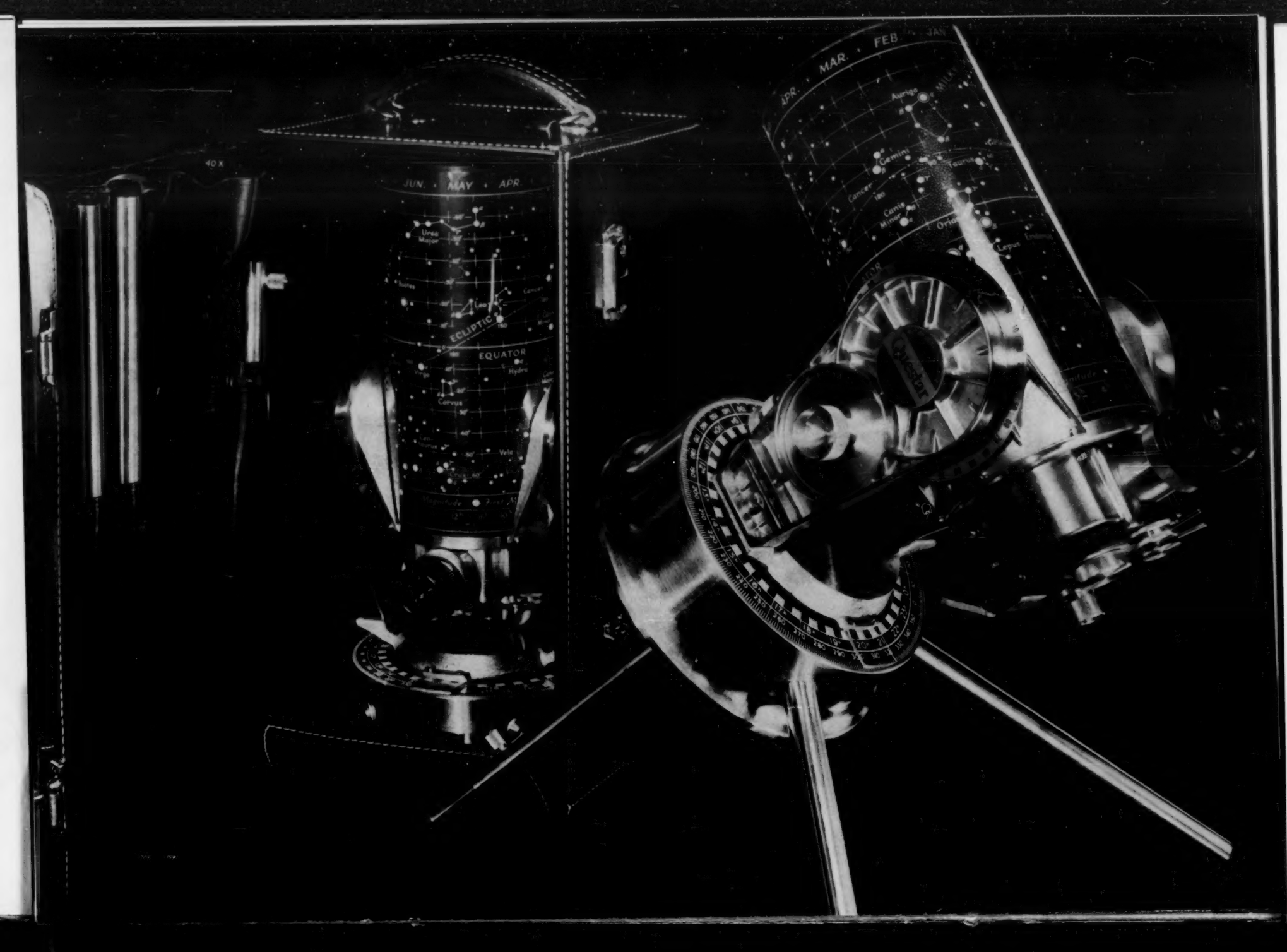
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ALL ABOUT THE STARS

Anne Terry White. Random House, New York, 1954. 144 pages. $1.95.

THIS IS an unusually competent bit of science popularization for young readers. Of the recent astronomy books for children, some are clearly by persons who know more about the stars than authorship, while a few are by professional writers whose acquaintance with astronomy is not adequate.

Mrs. White, however, shows a thorough and up-to-date grasp of her subject, and has an easy and clear way of telling about it. There is, for example, a chapter on Mars, written so that children can understand it, that outlines accurately today's conclusions about the possibility of life and the nature of the canals. Vivid word pictures of the sun and stars give some notion even of matters like the source of their energy.

The slips that I have noticed are exceedingly few and affect unimportant points only. Perhaps large numbers are sometimes used a little casually; they can be just blurs to the 10-to-14-year-old, for whom the dust jacket tells us the book is intended.

All About the Stars is intended to orient, rather than to be a how-to-do-it book. It suggests powerfully the empty vastness and yet fantastic variety of the heavens, and mankind's triumph in beginning to understand them.

MARTHA D. ASHBROOK
Weston, Mass.

RELATIVITY FOR THE LAYMAN

James A. Coleman. William-Frederick Press, New York, 1954. 131 pages. $2.75.

IF THE STUDENT or layman has both an ignorance of relativity theory and an interest in ameliorating that unhappy state, he now has in Professor Coleman's book an opportunity to rectify matters. He will not actually know relativity theory from reading this "simplified account of the history, theory, and proofs of relativity," but he should know much about it and should be inspired by his vision of the depth of thought underlying the concepts of both Newtonian and Einsteinian mechanics.

Coleman's book is intelligently put together, with the needs of the layman always in mind. For example, the first 35 pages are devoted to concepts that preceded the emergence of relativity theory. He discusses the measuring of the velocity of light and the early puzzlement about the ether. "Did the ether exist, or didn't it? If it did, why couldn't we detect it? And if it didn't exist, why didn't it?" Then Einstein came along with a simple explanation, and a revolution was set going.

The special theory of relativity, important in the microcosmos, and its experimental proofs, are sketched in sufficient detail, and then the general theory of relativity, important in the macrocosmos, along with its experimental proofs and its indications of the nature of the universe, is clearly presented. The volume ends with a brief statement on the unified field theory, which is "an attempt to deduce *all* the physical phenomena we know of from a few simple fundamental principles."

Remembering the audience to which this book is addressed, we find few shortcomings worth mentioning. The binding is not good on my early copy. But the printing is clear, the illustrations lighthearted, and the few mathematical formulae are not forbidding. The four-legged bugs that appear in one of the illustrations of one-, two-, and three-dimensional worlds may be accepted in a book on relativity, but the reviewer hopes nevertheless that the new edition, which he believes this excellent introduction soon will merit, will provide for the extra pair

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of legs that were always allotted to the hexapods in the pre-relativity days.

In referring to the test of the general theory by way of the advance of the perihelion of Mercury's orbit, the author should not have omitted referring to the fact that Newtonian theory prescribes and we have observed a large advance of that perihelion. Planetary perturbations are the source of the motion. The Einstein correction takes care of the much smaller excess advance which the Newtonian theory cannot explain.

HARLOW SHAPLEY
Harvard College Observatory

NEW BOOKS RECEIVED

THE CRIME OF GALILEO, *Giorgio de Santillana*, 1955, *University of Chicago Press*. 339 pages. $5.75.

Prof. de Santillana is an authority on Galileo who recently published an English translation of the *Dialogue*. The present volume is a detailed account of Galileo's encounter with the Inquisition, and of the three centuries of controversy this provoked.

OF TIME AND THE CALENDAR, *Elisabeth Achelis*, 1955, *Hermitage House*. 132 pages. $2.75.

Mrs. Achelis, an active American advocate of calendar reform, writes a strong plea for the adoption of the World Calendar, whose advantages over the present Gregorian and other calendars are described at length.

BINOCULARS, TELESCOPES AND TELESCOPIC SIGHTS, *Truman Henson*, 1955, *Greenberg*. 515 pages. $9.50.

This book is designed to provide the amateur and sportsman with everything he needs to know about terrestrial telescopes, binoculars, and telescopic gunsights. An appendix lists the characteristics of 107 models of commercially available instruments of these types.

THE EQUATORIE OF THE PLANETIS, *D. J. Price*, editor, 1955, *Cambridge University Press*. 214 pages. $10.00.

Dr. Price has edited a 14th-century astronomical manuscript from the library of Peterhouse College, Cambridge, which he believes composed and written in the hand of Geoffrey Chaucer, whose previously known works include not only the *Canterbury Tales*, but also a treatise on the astrolabe. The manuscript explains the construction and use of a mechanical device for predicting the positions of the sun, moon, and planets, according to the Ptolemaic theory of the solar system.

Photostats of the manuscript are given, and its text is printed both in the original Middle English and in modern English. The editor explains in detail his reasons for ascribing this work to Chaucer, and gives a complete scholarly analysis.

FRENCH BIBLIOGRAPHICAL DIGEST — 2, SCIENCE, ASTRONOMY, *Georges Assie*, editor, 1954, *Cultural Division of the French Embassy*, 972 Fifth Ave., New York. 114 pages. No charge, paper bound.

This volume is a summary of current astronomical activity in France. In a 22-page chapter Dr. J.-C. Pecker tells about the organization of French astronomy, the training of astronomers, and current observational and theoretical research. A list of the principal French observatories gives their staff members, instruments, and fields of work. There is a bibliography of some 400 books and articles by French astronomers in 1949-1954, with brief descriptions of their contents.

According to the preface, this publication is available without charge to libraries, university departments, and scientists, for the series is intended primarily to make French scientific work better known in the United States. The book is written entirely in English, with the bibliography titles given in both languages.

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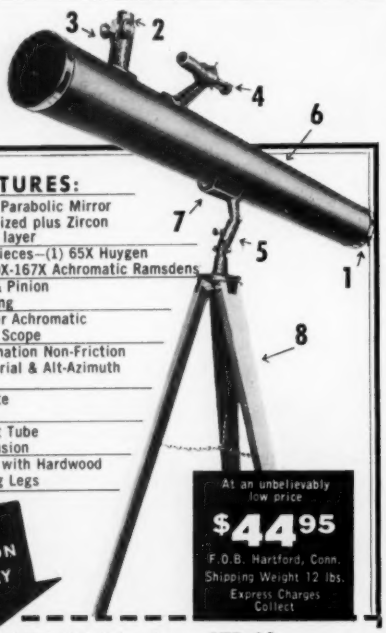

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MORE ECLIPSE NOTES

(Continued from page 263)

of the sun can be studied. Another program of the Tokyo astronomers involves the spectra of the outer chromosphere and the corona, to be recorded with a 12-inch reflector of 16½-foot focus, into which light will be fed by a 12-inch coelostat. Their third project is the photographic observation of the polarization of the corona's light, with four 4-inch f/23.5 cameras. From these photographs, made through colored and polarizing filters, it is hoped to derive contour lines of equal coronal brightness out to five solar radii, and to compare the polarization in different areas.

The Tohoku University astronomer, K. Takakubo, plans to photograph the corona with a 4-inch camera, using Lyot-type filters that transmit very narrow spectral regions.

The two-man Kyoto party will photograph the flash spectrum with three motion-picture cameras, each attached to a telescope, but with the three telescopes on a single equatorial mounting. The spectral regions will be blue-violet, red, and infrared.

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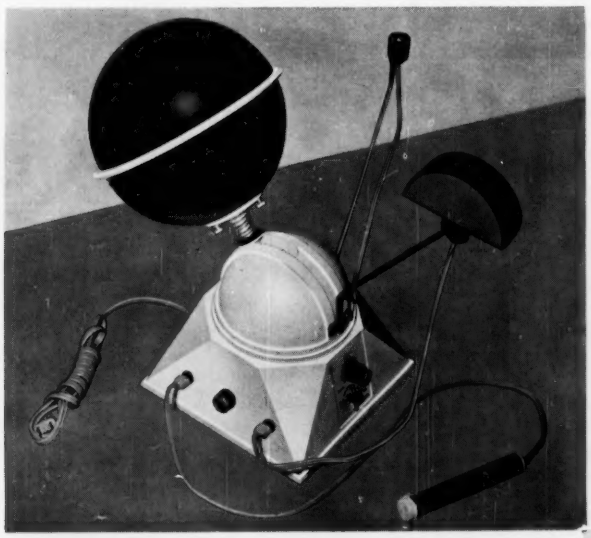

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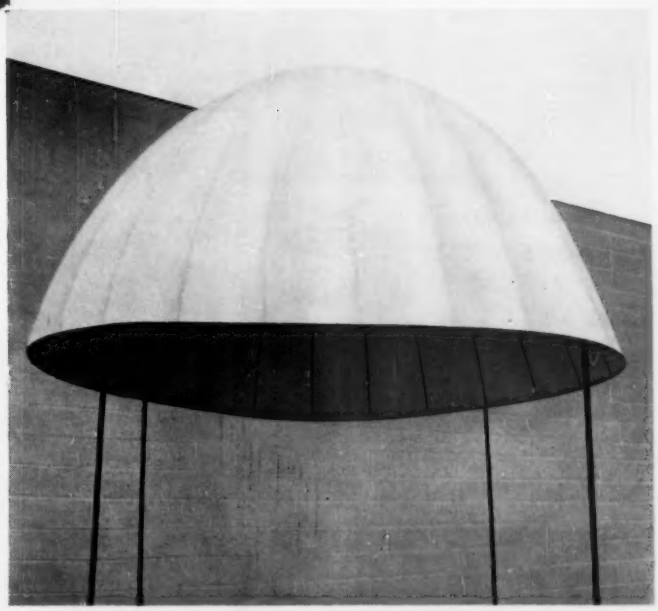

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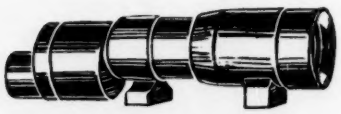

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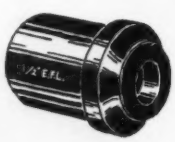

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NOTES ON BASIC OPTICS—XIII

N. Off-axis Image Points

The aberration of an optical system, as explained in March, is the difference between the actual path of a light ray and the prediction by the simplified equations we gave in January. We have seen that, if object point and image point are on the optical axis, spherical and chromatic aberration arise. If these points are not on the optical axis, several other types of aberrations have to be considered.

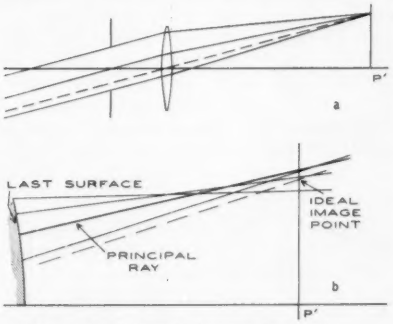


Fig. 44. Off-axis image formation.

1. **Distortion and Coma.** Fig. 44a shows ideal image formation for an off-axis point. Usually the aperture stop is separated from the lens. All the rays will meet in the paraxial image plane, at the point where the ray through the optical center and parallel to the principal ray meets this plane. (The **principal ray** is defined as the ray through the center of the entrance pupil.)

Ordinarily, the actual rays will not conform to the ideal imagery, and the case will resemble Fig. 44b. Here there is no perfectly defined image point anywhere; the various rays are unsymmetrically distributed around the principal ray; and the principal ray does not intersect the paraxial image plane at the point required for ideal imagery.

From this situation we can define two other aberrations. **Distortion** is the departure of the principal ray from the ideal image point; **coma** is the unsymmetrical deformation of the image patch.

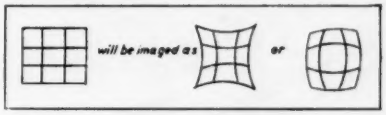


Fig. 45. Distortion of an image.

Distortion is positive if the principal ray meets the image plane closer to the axis than it should; negative, if it is farther away. This aberration leads to distorted images, whence its name. A square grid pattern will be imaged as barrel-shaped; if the corners are pulled in toward the center, we have positive distortion; if the corners are farther from the center than they should be, giving a pincushion shape to the image, the distortion is negative. The terms barrel distortion and pincushion distortion are often used. (See Fig. 45.)

Coma causes the image of a point to appear like a small comet. If the tail points away from the axis, the coma is positive. This aberration is the worst offender in parabolic mirrors.

2. **Astigmatism.** So far we have considered only rays in a single plane—the plane of the paper in the diagrams. To define the other two important aberrations, we must now visualize a three-dimensional picture. The plane that contains the optical axis and the object and image points is known as the **meridional** or **tangential** plane. This is the plane in which all of our diagrams have been drawn so far. The plane perpendicular to it is called the **sagittal** plane. Rays that lie in these two planes behave differently for off-axis points. For a point on the axis, the two planes are of course indistinguishable; for off-axis points, the distribution of angles of incidence for a bundle of rays is unsymmetrical about the principal ray for the tangential plane, while it is symmetrical for the sagittal plane.

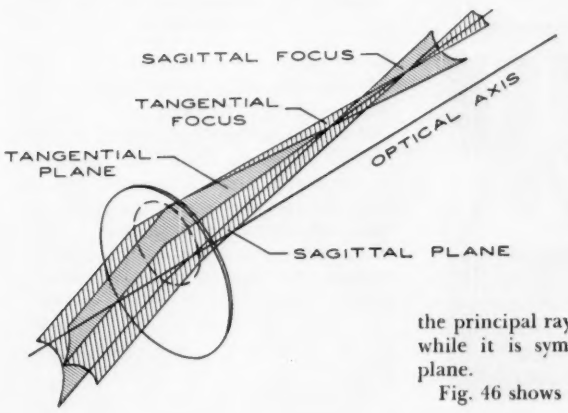
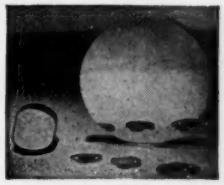


Fig. 46. An exaggerated diagram to show the different behavior of rays in the tangential plane (plane of the paper in two-dimensional diagrams) and the sagittal plane. Coma has been neglected in showing a point focus for the tangential rays.

Fig. 46 shows what occurs. The rays in



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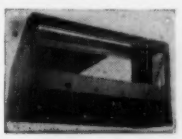

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the sagittal plane come to a precise focus on the principal ray (neglecting the effect of spherical aberration). If there were no coma, the rays in the tangential plane would also come to a point focus, but at a different distance from the lens. We have shown this condition in Fig. 46 to make it clearer. In an actual case, there will be spherical aberration and coma, and hence no actual point images at all if more than one pair of rays is considered.

The separation between the sagittal and tangential focal points is known as **astigmatism** (strictly, the astigmatic difference of focus). For a simple positive lens, the tangential focus will be closer to the lens than the sagittal focus.

3. **Field Curvature.** Neither the tangential nor the sagittal focus will be in the paraxial focal plane in most cases. This departure is called **field curvature**, since it increases with increasing distance from the optical axis, so that the images are formed on a curved surface. From what was said above, it is evident that there are two focal surfaces, the tangential and the sagittal, and that these are separated from one another.

If there is no astigmatism, that is, if the tangential and sagittal foci coincide, the image will be formed on a curved surface known as the Petzval surface, whose curvature can be computed from the parameters of the lens system. When there is astigmatism, the tangential and sagittal focal surfaces are separated from the Petzval surface in a ratio of 3:1—the tangential surface being three times as far away. By suitably choosing the lens characteristics, it is possible to bend the two focal surfaces almost at will, making

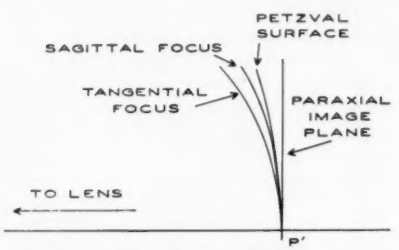


Fig. 47. The several kinds of focal surfaces all coincide only on the optical axis.

the curvatures positive or negative. The 3:1 ratio still holds, however, and usually it is impossible to bring the tangential and sagittal surfaces everywhere together. Fig. 47 shows the four focal surfaces as they occur in a simple positive lens—the flat paraxial image plane, the Petzval surface, and the tangential and sagittal surfaces. When we speak of the curvature of field of a lens, we usually refer to the Petzval surface.

In the preliminary stages of an optical design, it is usually desirable to choose characteristics of the system that will make the Petzval curvature come out

zero. But this is merely a starting point, for specification of the Petzval curvature will not describe the nature of the focal planes unless the astigmatism is known.

These six aberrations—spherical, chromatic, distortion, coma, astigmatism, and curvature of the field—are the most important ones in an optical system. In addition to these there are spherochromatism, the variation of spherical aberration with color; oblique spherical aberration, the spherical aberration of off-axis image points (associated very closely with coma); and lateral chromatic aberration, variation of distortion with color. There are still other, more subtle aberrations, described in advanced treatises. All of these must be taken into account in high-performance systems, like photographic lenses, but they need concern only those who actually perform optical design.

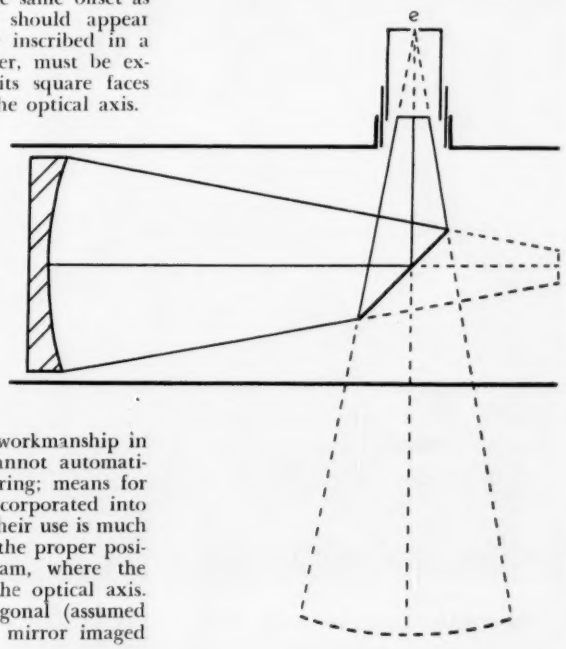
(To be continued)

Some Aids to Collimating a Newtonian

TELESCOPE collimation consists of bringing into line the axes of the objective lens (or mirror) and the eyepiece. In the Newtonian reflector, the eyepiece adapter tube is first mounted so that its axis intersects the axis of the telescope tube at a 90-degree angle. Then the mirror is installed, and its axis made to coincide with that of the tube.

The final step consists of inserting a diagonal so that the mirror's axis will be reflected to coincide with that of the adapter tube. This, the first of two conditions for perfect collimation, is effected by inclining the secondary reflecting surface 45 degrees to both axes. Also, the secondary should be placed so that the evenly illuminated portion of the deflected focal plane will symmetrically surround the adapter-tube axis. To meet this second condition, the diagonal should be centered on neither the mirror axis nor the adapter axis. Instead, it should be slightly offset, both away from the eyepiece and toward the mirror. The amount of offset, equal in both directions, depends mainly on the focal ratio of the mirror. At f/8 it is roughly 2.7 per cent of the diagonal's minor axis, and at f/4 roughly 5.4 per cent. A diagonal so placed is said to be *optically centered.*

A rectangular diagonal, apparently square when viewed through the adapter tube, should be given the same offset as an ellipse. The mirror should appear imaged in it as a circle inscribed in a square. A prism, however, must be exactly centered, so that its square faces symmetrically surround the optical axis.



The need for offsetting the secondary reflector or diagonal, toward the mirror and away from the eyepiece, is shown here. The primary mirror is at the left, but is seen by the observer as if it were in the position dotted at the bottom of the diagram.

Even the most careful workmanship in building the telescope cannot automatically assure optical centering; means for adjustments should be incorporated into the secondary support. Their use is much simplified if the eye is in the proper position, at **e** in the diagram, where the bounding field rays cut the optical axis. From this point the diagonal (assumed to be elliptical) and the mirror imaged within it are of the same apparent size, so their outlines can be made to coincide. The distance of **e** from the axis of the telescope tube is, with negligible error, equal to **fw/a—w**, where **f** is the focal length of the mirror, **a** its aperture, and **w** is the width or minor axis of the diagonal. You will need an extra adapter tube of about double the usual length, capped with a 1/16" centered peephole.

Seen through the peephole, the mirror reflection must appear concentric with the inner open end of the adapter tube. Within the imaged mirror are seen, via two reflections, the spider vanes and the round outline of the elliptical diagonal. (Except in a low-ratio telescope, the radial offset of the latter may not be noticeable.) Finally, within the secondary's image there is seen, via three reflections, the interior of the adapter tube capped by its peephole. The tube-wall interior must appear as a symmetrical ring, as if the tube were pointing squarely away from you. It and the peephole reflection must be exactly centered in the mirror image. When these requirements have been met, the adjustments are complete, and the collimation is quite perfect.

Much depends upon personal judgment, but a positive check is possible with the *double eyepiece test.* In principle, one eyepiece is inserted in the adapter tube, and another of lesser power is used

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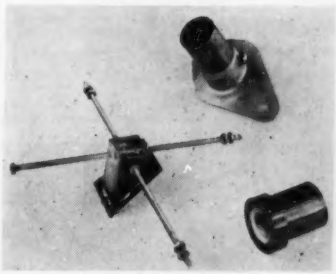

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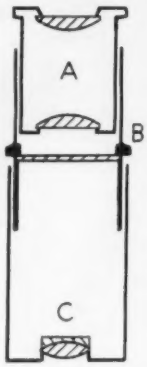
to examine the exit pupil. It is more convenient to replace the two eyepieces by their equivalent—a small low-power telescope that will fit in the adapter tube.



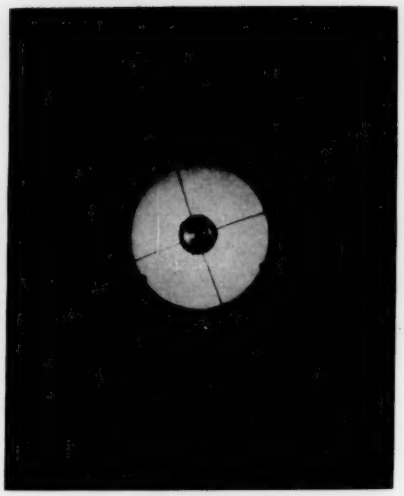
Right: This photograph by Allyn J. Thompson shows the exit pupil of a perfectly collimated Newtonian, with the camera lens replacing the eyepiece. The adapter tube was capped with a perforated aluminum plug, and the camera lens placed close to this peephole, focused for the distance to the mirror.

Left: The double eyepiece or two-power telescope.

For this purpose I designed the two-power telescope and easily made reticle illustrated here.

War-surplus lenses were used. **A** is a 1" Ramsden eyepiece, and **B** is a separate part containing the reticle. The latter is 1/16"-thick lucite, on which were inscribed two concentric circles—the smaller for f/8 mirrors, the larger for f/4 mirrors. **C** is a 2" length of 1¼" outside-diameter tubing containing an objective lens of 2" focus. This lens acts as the first of the dual eyepieces, and its focal length was chosen as giving a satisfactorily large exit pupil.

The size for the reticle circle can be determined from the formula for exit-pupil diameter: mirror diameter divided by magnification. The latter is the focal length of the mirror divided by the focal length of the lens in **C**. It is better, however, to make the circle a little larger than the exit pupil, to distinguish between them.



In use, first insert **C** a convenient distance into the eyepiece adapter tube. The eyepiece **A** is pushed into **B** until the reticle circle is in focus, and the two as a unit are then inserted into **C** until the mirror image is seen in sharp focus on the reticle.

The mirror image must now be centered on the reticle circle. The reflection of the spider vanes, secondary, and adapter tube will not be seen in sharp focus because they are, via the extra reflections, considerably farther from **C** than is the mirror. Accordingly, **A** must be pushed a trifle farther into **B** to focus on the images. Under magnification, the offset of the diagonal may now be noticeable. But the adapter-tube interior and the lower end of **C**, now seen in the secondary's image, must be exactly centered with respect to the mirror image.

Adjustments can now be made in comfort, ending by having the mirror image concentric with the reticle circle. With this device, the diagonal's inclination can be corrected to within a few minutes of arc.

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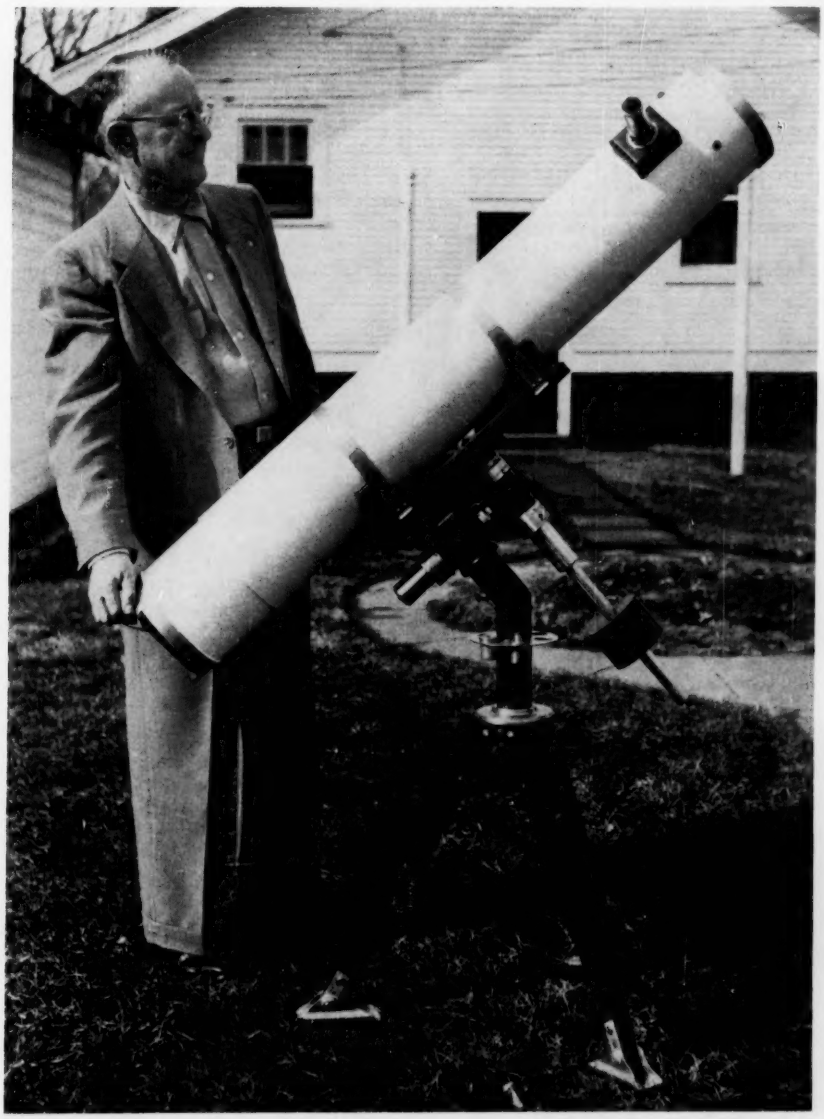
My intention was to work when convenient, with no time set for completion of the instrument. The telescope, finished during January, 1955, had careful work lavished on the various parts to insure good performance and appearance.

In spite of following such detailed instructions as in Allyn Thompson's book, *Making Your Own Telescope*, I did not achieve a paraboloid. The mirror was finished for me by a professional optician.

The tube is of paper and in two sections, one telescoping into the other, a valuable feature in the final adjustment of the instrument for focal length. The tubing soaked up considerable quantities of sealer and two coats of enamel primer, each well sanded. Three coats of eggshell white enamel were applied to the exterior and the interior was given two coats of flat black enamel. Wherever holes were drilled in the tube for fastening various components, lacquer was applied to harden the paper.

Aluminum hoops, $\frac{1}{8}$" by 1", were accurately fitted, then welded and driven onto the ends of the tubes with a hammer and a wooden block. The mirror mount at the lower end of the telescope tube is held by three threaded studs.

The saddle is of walnut, and the tripod legs are selected straight-grained cherry



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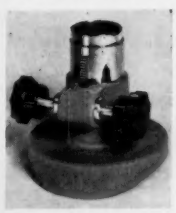

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with brass bushings where they join the cast-bronze tripod head. It was necessary to fit these legs with safety ladder shoes in order to support the weight of the telescope on soft ground. The aluminum straps and ways on the saddle are lined with felt.

The tees of the mounting head are 1½" bronze, except that one has a 2" opening to fit the 2" iron pipe in the upright. It was easier to cut this pipe and weld it at an angle than to use a 45-degree tee, and the angle is correct for my latitude of 39° 52'. The axes were turned from extra heavy 1¼" iron pipe with a taper of 0.001" to the inch.

Before assembly with the axes, the bronze tees were tinned on the inside; then they were filled with babbitt, and the bearings were later scraped for a very smooth and almost perfect fit.

I had trouble with the oil and lampblack mixture recommended to keep the babbitt metal from sticking to the axes. The bearing surfaces were badly pockmarked, apparently by the oil vaporizing in contact with the hot metal. Talcum powder is far superior, and with it clean, smooth bearing surfaces can be obtained.

For a good babbitt job, it is most important to provide for separating the shaft from the poured bearing, preferably while the work is still hot. My shafts were released by tightening an iron tee on the threaded axis end, forcing the bearing tee toward the opposite and smaller-diameter shaft end. Movement was limited because of the taper in the pipe threads, for this required backing off and adding washers until the shaft was free.

The disk mounted above the tripod head holds six eyepieces. It is not only a convenience but is a safe way to keep eyepieces under observing conditions at night.

The telescope needs a small finder that will soon be added. Later, setting circles and perhaps a clock drive will be constructed. Building a telescope is a wonderful outlet for craftsmanship in a variety of materials and methods.

E. J. ANDREWS
2262 N. Church St.
Decatur, Ill.

CHICAGO SOCIETY BEGINS LARGE REFLECTOR

ON FEBRUARY 13, 1955, two 12¼-inch mirror blanks and eight pounds of carborundum were obtained at the Adler Planetarium, and on the evening of February 14th rough grinding was begun by Joseph A. Anderer, president of the Burnham Astronomical Society, Chicago, Ill. Thus, the project to build a large telescope for our group is finally under way.

This report of the Burnham telescope committee describes our reasons for choosing a 12¼-inch reflector of focal ratio f/8. These may be of value to other

groups planning the construction of a telescope, as we took into consideration the advantages and disadvantages of diameters from eight to 24 inches and focal ratios from f/4 to f/12.

1. The most useful instrument for an amateur or a group of amateurs is one for direct visual observing. Furthermore, the professional astronomer has large and elaborate equipment that may not be entirely satisfactory when used visually.

2. The seeing conditions in Chicago and vicinity are seldom good enough to use a very large aperture to full advantage. Light would reach a 24-inch mirror through a column of atmosphere almost four times as large as the column used by a 12¼-inch.

3. The cost and know-how required for this telescope are within the funds and capabilities of the society's members. It should be possible to make a telescope of exceptionally fine quality, which might not be the case with a larger instrument. The construction time would also be reduced to one fourth or one eighth the time required for a 24-inch. For a long-term project, enthusiasm in a group normally wears down as the length of time increases. We think that we can have a completed telescope within a year.

4. The f/8 focal ratio requires a tube less than nine feet long. Properly mounted, the eyepiece would never be more than nine feet from the ground. This may seem a bit long when compared with the average amateur's instrument, but the gain in resolution of fine lunar and planetary detail by keeping the diagonal to a minimum diameter is worth the extra length. As far as tolerance is concerned, the deviations from a perfect figure could be almost 20 per cent. This is according to F. B. Wright *(Amateur Telescope Making, 1)*. The Burnham telescope will not, however, be figured to only within 20 per cent; the statement merely indicates that a mirror of this size and focal ratio is within the capabilities of an amateur group like ours.

5. Because the basic essentials can be constructed with the money now in the society's telescope fund, it will probably be possible to add a number of accessories and refinements without undue strain on the society budget.

6. One of the greatest problems encountered in planning a large telescope is where to mount it. The cost of the land and the building could well be several times greater than for the instrument itself. This problem is almost eliminated with a 12¼-inch. At present we have no property on which to mount our instrument permanently, but rather than wait until this is procured, we will construct the telescope in a manner to permit moving it around.

It will not be built as a portable telescope, however, and nothing will be sacrificed for portability. The pedestal, mounting, counterweight, and tube will be separable, but of the mass and rigidity required by a permanently mounted instrument. These units will be attached to one another by a six-point kinematical support system as outlined in Strong's *Procedures in Experimental Physics*. This will make use of the telescope possible at any suitable site. It is to be group made and group owned, and as few as two or three members should be able to assemble it and take it apart.

TELESCOPE COMMITTEE
Burnham Astronomical Society
Adler Planetarium
Chicago 5, Ill.

SKY-SCOPE

COMPLETE AS ILLUSTRATED $29.75

The full 3½-inch diameter reflecting type astronomical telescope that even the telescope makers talk about.

It has been sold for more than 15 years and now is on display in at least two U. S. planetaria. It will show mountains and craters on the moon, Saturn's rings, Jupiter's four moons and the planet's markings, and close double stars with guaranteed observatory clearness. Skyscope enjoys worldwide distribution.

Every instrument, with its ¼-wave, aluminized mirror, is individually tested before being packed for shipment. We suggest that before buying you inquire at almost any local astronomy society about the efficiency of Skyscope.

We invite your attention to our free and straightforward descriptive brochure which also shows a photograph of the individual parts used.

125-power and 35-power extra eyepieces	**$5.15 each**
Six-power finder, with brackets	**$7.50**
Holder for extra eyepieces	**$1.00**

THE SKYSCOPE CO., INC. **475-s Fifth Avenue, New York 17, N. Y.**

SKY-GAZERS EXCHANGE

Classified advertising costs 15 cents a word, including address; minimum charge, $3.00 per ad. *Remittance must accompany order.* Insertion is guaranteed only on copy received by the 20th of the second month before publication; otherwise, insertion will be made in next issue. We cannot acknowledge classified ad orders. Sky Publishing Corporation assumes no responsibility for statements made in classified ads, nor for the quality of merchandise advertised. Write Ad Dept., Sky and Telescope, Harvard Observatory, Cambridge 38, Massachusetts.

FREE CATALOG: Telescopes, binoculars, microscopes. Complete line of quality parts for telescope making. Harold Snyder, 705 Leopold St., Huntington, Ind.

TELESCOPES and all accessories bought, sold, or exchanged. Valley View Observatory, 106 Van Buren St., Pittsburgh 14, Pa. Established 25 years ago.

WANTED: 5" or 6" refractor telescope or 5" or 6" objective. Please write Bill Ashdowne, 18450 Grand River, Detroit 23, Mich.

WANTED: Unitron 4" altazimuth in good condition. A. Pernick, Locust Hill Rd., Albany 3, N. Y.

FOR SALE: 6" RFT reflector f/4.5, perfect paraboloid. Rigid tripod, equatorially mounted, finder, two eyepieces, diagonal. $100.00. Frank Shimkus, Box 936, Windham, Ohio.

FOR SALE: 6" reflector, good equatorial mount, $120.00. Photos, description. John McQuaid, 2003 High, Logansport, Ind.

MOUNTED 5" and 6" refractor objectives of first quality, $200.00 and $300.00. 4" edged blanks, $22.50. Correspondence invited. Earl Witherspoon, Sumter, S. C.

FOR SALE: Airspaced achromatic objectives. 2.6" aperture, 20" focal length. Collimator quality. Reduced secondary spectrum. Unmounted. $20.00. Limited supply. A. E. Gee, 315 Beard Ave., Buffalo 14, N. Y.

FOR SALE: 6" Esco reflector. Perfect condition. 75" long, 2 eyepieces, finder. $125.00. David Agnew, 2337 Fairhaven Rd., Davenport, Iowa.

INTERESTED in the cosmic collision theories of geology? See a copy of *Target: Earth*—The Role of Large Meteors in Earth Science, by Kelly-Dachille. 263 pages and 117 illustrations. Price $5.00. Address: Target: Earth, 1781 E. Baars St., Pensacola, Fla.

ILLUMINATED drawing and chart board for use at telescope. De luxe electric model, many features, $3.50 postpaid. Self-contained field model soon available. Write for full descriptions. ALPO Mars map, $1.00 postpaid. Color slides of planetary drawings. Books. Complete reflecting telescopes and accessories. Free lists. D. P. Avigliano, 678 W. Manzanita Ave., Sierra Madre, Calif.

STAMP DEALER will trade large U. S. collection for professionally ground 8" to 12" reflector telescope. R. Nieman, 223 N. Elm, Hinsdale, Ill.

ATTENTION Sky-Gazers: Use both eyes in your usual observations—you'd be surprised at the results. For sale, imported 30x binocular-scope, $195.00 (three available). Get ready for Mars. Excellent, specially prepared 6" planetary reflector, f/12, portable equatorial tripod, 8x finder, $195.00. Photos, details of above items on request. Will accept part trade optical equipment. Brayton Optical Exchange, 5123 Eagle Rock Blvd., Los Angeles 41, Calif.

OUT OF PRINT books. Write for catalogue listing hundreds of items. Charles Benevento, 363 Atlantic Ave., Brooklyn 17, N. Y.

BAUSCH-LOMB Balscope Sr. with 20x and 60x eyepieces and trinod adapter in perfect condition. $80.00. Chas. Miller, 200 W. 6th, Gary, Ind.

FOR SALE: Brass rack-and-pinion eyepiece holder, 2" movement, takes standard 1¼" eyepiece. Price $5.95 postpaid. Satisfaction or money refunded. Donald Lehr, 31 S. Hood Ave., Audubon 6, N. J.

AMATEUR ASTRONOMER'S *Handbook*, by Sidgwick, just published, $12.50; Norton's *Star Atlas*, $5.25; Richardson, *Exploring Mars*, $4.00; Moore, *Guide to the Moon*, $3.95, *Guide to the Planets*, $4.95. All books reviewed in Sky and Telescope. Foreign and domestic publications. Write for list. Herbert A. Luft, 42-10 82nd St., Elmhurst 73, N. Y.

PLANETARY OBSERVER'S *Bulletin*: Nontechnical, complete magazine for the amateur. Observing projects, articles, latest astronomical news. Eight months (four double issues), $1.00. Sample copy 25¢. Write: R. N. Hartman, 2327 Glencoe, Venice, Calif.

TELESCOPE MIRRORS. Revolutionary prices—the lowest yet offered. Completely finished, ready to mount. Send for free literature. Aurora Telescope Co., 266 Ave. C, Bayonne, N. J.

LOWEST PRICES: All sizes, binoculars, telescopes, microscopes. Amazing 48-page free catalogue. Joe's Binocular House, 4827 Second St., Detroit 1, Mich.

REFRACTING TELESCOPE, 3" coated objective, four feet long. Hundred dollars or trade for 10 x 50 Bausch and Lomb binoculars. Clive Payne, Granite Falls, N. C.

WHAT'S NEW AT EDMUND'S
by Norman W. Edmund

Dear Fellows:

We are adding so many new items to our astronomical line that I would like to call them to your attention in this column.

It took us a long time to find a real good manufacturer of a low-priced 3" objective for a refractor. We got our first shipment of these two months ago and immediately sent some out for testing, and sold a few in our retail store. The comments have not only been favorable but also full of praise, so we are quite excited here about it.

We are now working on a metal cell, a refractor rack-and-pinion eyepiece holder, and a tripod and mount. We already have tubing available. So very soon *you* will be able to put a good 3" refractor together at a real saving.

For those who want a ready-made scope we have had some of these objectives made up into completed telescopes using a war-surplus elbow telescope at the eyepiece end. As this instrument has built-in filters and an erecting prism you get a swell scope at a price very substantially lower than other 3" refractors. Read the other facts about it in this ad.

Now you can get a Barlow lens to increase the power of your scope for only $3.00! Right away you will want to know how it compares to the $15.00 and $17.50 ones of similar focal length. We sent samples for testing to three experts and the answers were all the same. On and around the axis this $3.00 Barlow is just as good as the more expensive ones. On the edge of the field you get some slight color.

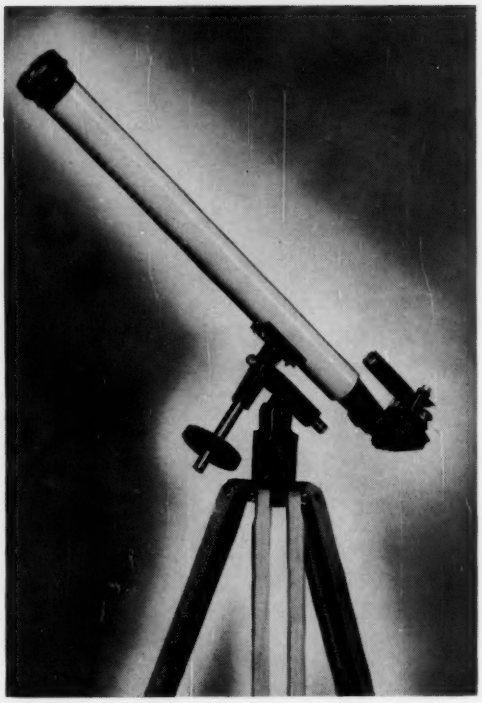
To make it easy for you to use this Barlow lens we have had made and blackened some sets of brass tubing that is just the right size to hold the lens and to fit 1¼" eyepieces and holders.

I walked into a surplus dealer's warehouse the other day and there were some beautiful 4" diameter 360° dials. The markings on these were the nicest I have seen on a dial, and his papers showed government cost to be over $6.00. After much dickering, I got the lot and we can offer them to you for only $1.25 each — a real value at this price, and we are including an air-speed computer with each one in case you need the plastic for the center part, and so forth.

Keep watching our ads, fellows, for we have many new items coming!

40-90-190 POWER 3" REFRACTOR TELESCOPE

Complete With Equatorial Mount, Tripod and Prism Finder! Erects Image at All Powers!

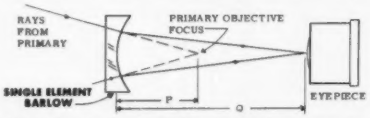


Here's a telescope bargain you have never seen before. This telescope uses the 3" objective described on the opposite page. Telescope is complete — no extras to buy. Look at all of these wonderful features. Erect image. Amici roof prism. Bends the light at 90° angle for comfortable viewing at zenith and also for terrestrial use. Three eyepieces supplied with the telescope: 0.6 mm. for high-power astronomical viewing, 12.5 mm. for medium power for viewing moon, planets, etc., and 28 mm. for low-power terrestrial and astronomical use. Small focusing eyepiece mount takes 1¼" outside diameter eyepieces. Contains built-in filters which can be changed by turning a small knob. Filters are red, yellow, neutral, and clear for use in planetary work.

The 8-power finder telescope has a real achromatic objective. Bends the image in a right angle for convenience in transferring your eye from the finder to the telescope. The heavy-duty equatorial mount can be adapted for all latitudes in astronomical viewing. It is quick and flexible for terrestrial use. Specially designed to adapt easily to slow-motion mechanism. Heavy-duty tripod adjustable for viewing at all heights. Overall length of telescope approximately 45". Shipping weight 100 lbs.

Stock #85,019-Y ..... $195.00 f.o.b. Barrington, N. J.

DOUBLE AND TRIPLE YOUR TELESCOPE'S POWER with a BARLOW LENS



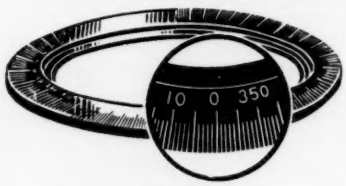
WHAT IS A BARLOW? A Barlow lens is a negative lens used to increase the power of a telescope without resorting to short focal length eyepieces, and without the need for long, cumbersome telescope tubes. Referring to the diagram above, a Barlow is placed the distance P inside the primary focus of the mirror or objective. The Barlow diverges the beam to a distance Q. This focus is observed with the eyepiece in the usual manner. Thus, a Barlow may be mounted in the same tube that holds the eyepiece, making it very easy to achieve the extra power.

The new power of the telescope is not, as you might suppose, due to the extra focal length given the objective by the difference between P and Q. It is defined as the original power of the telescope times the quotient of P divided into Q!

ACHROMAT OR SIMPLE BARLOW? An achromatic Barlow lens will give best results, but our low-priced single-element lens will give you 90% of the performance of the achromat. In fact, on and around the axis, the image will be just as good, with slight additional color at the edges of the field.

SINGLE ELEMENT BARLOW—FOCAL LENGTH 1-5/16"
Unmounted, O.D. 1-3/16". Coated.
Fits in tubing listed at right.

Stock #30,175-Y ..... $3.00 ppd.



360° SETTING CIRCLE

Made of heavy black plastic material with white markings divided into 1 degree. Numbered every 10 degrees. Diameter 4". Hole diameter 2¾" with a ledge 3¼". We also include, free of charge, the U.S. Air Force true air-speed computer, which is an instrument made of two disks of black plastic. This may be used in conjunction with the setting circle if you plan to make your own.

Stock #60,039-Y ..... $1.25 ppd.

BRASS TUBING

2 pieces, 3" long, slide fitting. Blackened brass. I.D. 1-3/16", O.D. 1-5/16". To fit single-element Barlow at the left. Complete directions.

Stock #40,165-Y ..... $1.25 ppd.

EDMUND SCIENTIFIC CORP.

A Sensational Offering!

3" ACHROMATIC TELESCOPE OBJECTIVE

Real Quality at an Unbelievable Low Price

MAKES A WONDERFUL 3" REFRACTOR

ONLY $28.00 ppd.

3-1/16" diameter, with 45" focal length. These were tested in the field by Hal Metzger, famed amateur, and pronounced "equal to any 3" objective made anywhere today, even at two or three times the price". Letter is in our files. This is an air-spaced achromat. The air-spacing of a lens gives the lens designer four surfaces with which to correct aberrations, instead of only three surfaces, as with a cemented achromat. The result is a beautiful, color-free image, an image which is sharp, clear, with very flat field, no bad zones and fully corrected against coma. This objective is not coated, for experience has taught us that after many cleanings a coated objective tends to scatter light and become inferior to a well-cleaned uncoated glass. This is your chance to build a 3" refractor at low cost. A refractor with a lens as good as this one would cost you about $400.00, if bought ready-made! We supply free with this lens a specially designed, spiral-wound laminated Kraft board mount which is designed to slip over our 3" aluminum tube. This effectively solves your mounting problem.

COLOR-CORRECTED! AIR-SPACED!

STOCK #30,166-Y — 3" Achromatic Objective
Color-corrected — air-spaced ..... $28.00 ppd.

Coming Soon! From the same manufacturing source, 2" x 50" f.l. and 4" x 60" air-spaced achromats! If you want information on these new objectives, write for Bulletin #30. We will send it as soon as it becomes available.

4¼" ASTRONOMICAL TELESCOPE

BRAND NEW! 'Palomar, Jr.'

ONLY $74.50 COMPLETE

A REAL REFLECTOR TELESCOPE
Complete with Equatorial Mount, Tripod

Rack and pinion, micrometer-smooth focusing with tension adjustment. Two-piece rigid diagonal construction. All-aluminum black anodized tube. No-distortion adjustable mirror mount, easily removed for mirror cleaning. Tube ventilated. Real equatorial mount — one smooth motion follows stars, planets. Sturdy hardwood tripod. Counterweight for perfect balance.

Stock #85,006-Y ..... complete, $74.50 f.o.b.

"MAKE-YOUR-OWN" 4¼" MIRROR KIT

The same fine mirror as above, polished and aluminized, lenses for eyepieces and diagonal. No metal parts.

Stock #50,074-Y ..... $16.25 ppd.

7X — FINDER TELESCOPE — ACHROMATIC

Stock #50,080-Y Finder alone, less ring mounts $9.95

Stock #50,075-Y Ring mounts per pr., $4.95

ASTRONOMICAL TELESCOPE TUBING

Stock No.	I.D.	O.D.	Lgth.	Description	Price
80,038-Y	4⅛"	5¼"	46"	Spiral-wound paper	$2.50
85,008-Y	7"	7½"	60"		4.00
85,011-Y	2⅞"	3"	48"	Aluminum	6.00
85,012-Y	3⅞"	4"	60"		8.75
85,013-Y	4⅞"	5"	48"		9.00
85,014-Y	6⅜"	7"	60"		15.00

All tubing is shipped f.o.b. Barrington, N. J.

HUYGENS EYEPIECES

Here are some really terrific values in eyepieces! The three eyepieces listed below are manufactured by one of the world's best producers of optical components. We have searched the world's markets, including Germany and France, to find a real quality eyepiece. The image clarity, the workmanship evidenced in the metal parts, will prove the skill and experience of Goto Optical Company, Tokyo. Guaranteed terrific buys at these low prices!

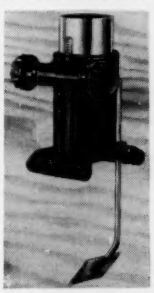
HUYGENS TYPE — STANDARD 1¼" DIA.
6 mm (¼") Focal Length
STOCK #30,063-Y ..... $8.50 ppd.
12.5 mm (½") Focal Length
STOCK #30,064-Y ..... $8.00 ppd.

COMBINATION EYEPIECE
STOCK #30,065-Y ..... $9.00 ppd.

This Huygens eyepiece, used in different arrangements of the lens elements, gives focal lengths of 10 and 20 mm, allowing you to double the power of any objective or primary mirror. Standard equipment with our Palomar, Jr. reflecting telescope. Easy directions for assembling for different powers are included.

RACK & PINION EYEPIECE MOUNT

. . . Available with Diagonal Holder



Now—you can improve performance in a most important part of your telescope—the eyepiece holder. Smooth, trouble-free focusing will help you to get professional performance. Look at all these wonderful new features: Real rack and pinion focusing, with variable tension adjustment, gives you microscope-smooth focusing action. Focus travel over 2". Drawtube accommodates standard 1¼" eyepieces, giving your present telescope a wide, varied range of power. Standard size opening also allows the use of accessory equipment, such as sunspot projectors, filters, eyepiece prism diagonals and terrestrial erectors. Lightweight aluminum body casting. Rigid mounting achieved by drilling four small holes in tube, whether paper or metal. Drawtube and rack chrome plated brass, body in black wrinkle finish.

Stock #50,077-Y (less diagonal holder) 9.95 ppd.
Stock #60,035-Y (diagonal holder only) 1.00 ppd.

MOUNTED ERFLE EYEPIECE

68° FIELD OF VIEW

Consists of 3 coated achromats in metal mount with spiral focusing. F.L. 1¼". Dia. 54 mm., length 54 mm. War surplus. Govt. cost about $84.00. This is the type war surplus bargain that will be talked about in years to come. Buy while you can. Our price will jump soon.

Stock #5160-Y, 12.50 ppd.

WAR SURPLUS TELESCOPE EYEPIECE

Mounted Kellner Eyepiece, Type 3. 2 achromats, F.L. 28 mm., eye relief 22 mm. An extension added, O.D. 1¼", standard for all types of telescopes. Govt. cost $26.50.

Stock #5223-Y, 5.95 ppd.

SPHERICAL TELESCOPE MIRRORS

Ground, polished, aluminized, silicon monoxide overcoated. You can't buy better quality. Remember, good Spherical Mirrors of f/10 and higher, are perfectly satisfactory for reflecting telescopes.

STOCK NO.	DIAM.	FOCAL LENGTH	PRICE
50,082-Y	3"	30"	$9.95
50,051-Y	4¼"	45"	15.00

RIGHT ANGLE PRISMS

Excellent for use as a diagonal on a Newtonian telescope. Also used in refractors to bend light rays for more comfortable viewing. For dimensions, refer to the diagram. These are all within ¼ wave length tolerance.

STOCK NO.	Dimension of Faces	Price ppd.
3252-Y	24 x 24 m.m.	$2.50
3155-Y	31 x 31 m.m.	3.00
3255-Y	38 x 35 m.m.	3.50
3169-Y	41 x 40 m.m.	3.00

BE SURE TO GET FREE CATALOG "Y"
Fantastic variety — never before have so many lenses, prisms, optical instruments, and components been offered from one source. Positively the greatest assembly of bargains in all America. Imported! War Surplus! Hundreds of other hard-to-get optical items. Write for *Free Catalog "Y"*.

LATEST MODEL SPITZ Jr. PLANETARIUM

Designed by Armand Spitz. Projects nearly 400 stars, more than 70 constellations in their correct relationships. Use it in any darkened room of the house, project it on walls and ceiling. No batteries, works on ordinary household current. Two simple adjustments that show you the sky as it appears from any point in the Northern Hemisphere . . . for any time of night . . . for any month of the year! Rheostat brightness control. A 32-page book included free of extra cost. Contains valuable information about the stars, provides easy identification of the constellations. Also FREE — illuminated pointer.

About 14" high on a 7" x 7" base. Projection sphere 7" diameter. Weight 3 lbs. Now available supplementary spheres for Southern Hemisphere and "Sky Zoo". Write.

Stock #70,040-Y ..... $14.95 ppd.

MISCELLANEOUS ITEMS

MOUNTED BARLOW LENS — Short Focal Length. E.F.L.: —1.74±0.01 inches. Clear aperture: 0.96" O.D. of cell: 1⅛".
Stock #30,140-Y ..... 15.00 ppd.

STAR SPECTROSCOPE — Imported! Doubles the usefulness of your Telescope. 2¾" long.
Stock #50,023-Y ..... 32.75 ppd.

60° SPECTROMETER PRISM — Polished surfaces 18 mm x 30 mm — flat to ½ wave length.
Stock #30,143-Y ..... 8.25 ppd.

COMING! — 6" Equatorial Mount suitable for 6" or 8" Reflecting Telescopes.

ORDER BY STOCK NUMBER . . . SEND CHECK OR MONEY ORDER . . . SATISFACTION GUARANTEED!

BARRINGTON • NEW JERSEY

BAUSCH & LOMB

BALscope Sr.

Bausch & Lomb BALscope, Sr. is a highly precise, compact 60mm telescope. A deserved favorite for beginning astronomers, it also serves the advanced field as an adequate commercial version of a richest field telescope. Choice of four eyepiece powers as listed below. (With any of the three lower-power eyepieces, BALscope, Sr. is also an outstanding general observation terrestrial telescope.)

Eyepiece power	Exit Pupil diameter	Angular field
15×	4.0mm	2°40′
20×	3.05mm	2°5′
30×	2.0mm	1°28′
60×	1.0mm	0°33′

BALscope, Sr. with 15×, 20×, 30× or 60× eyepiece $95.00

Extra eyepieces, each..... 25.00

Tripod adapter (permits use of BALscope, Sr. with any pan-head camera tripod)... 6.85

WRITE for descriptive folder. Bausch & Lomb Optical Co., 25841 Lomb Park, Rochester 2, N. Y.

OBSERVER'S PAGE

Universal time is used unless otherwise noted.

DEEP-SKY WONDERS

NINETEENTH-CENTURY handbooks for the amateur bulge with data on double stars. William Herschel's discovery that stars revolve around each other had extended the sway of gravitation far beyond the bounds of the solar system, powerfully appealing to men's imaginations.

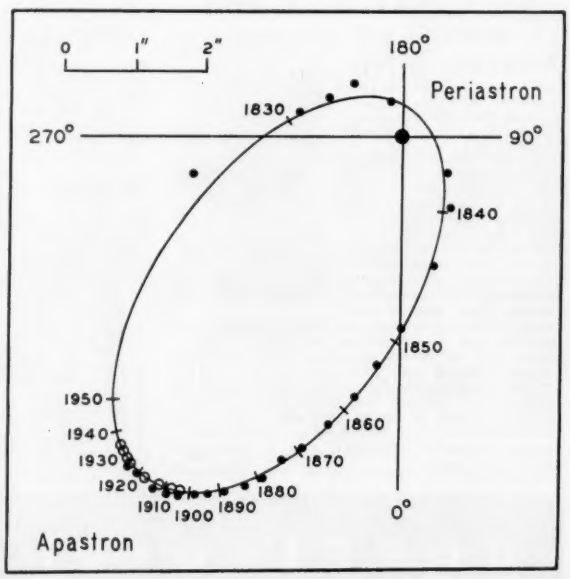
Of all the double stars none got more attention than Gamma Virginis. Its components are each as bright as magnitude 3.7. For all but a few months of its 171-year period it is easily resolved by small telescopes. Ordinarily the companion drags slowly along its orbit, but in four short years near periastron it swings through 180 degrees in position angle, its motion evident in a 10-inch telescope from month to month.

Pound and Bradley observed the pair in 1718, and Cassini noted it as double during a lunar occultation in 1720, later splitting it with his 16-foot telescope. But the matter seems to have been frequently forgotten, and as late as 1794 four astronomers watched an occultation of this star without noticing its duplicity. John Herschel's orbit of 1833 predicted a close but visible periastron passage. Admiral Smyth, going to his 6-inch refractor one morning in January, 1836, found to his astonishment that Gamma appeared single, and that no teasing even with powers up to 1,200 would elongate the disk in the slightest. John Herschel, at the Cape of Good Hope, had a similar experience with a larger telescope. But in a few months the disk became elongated and Gamma was again measurable as two stars.

The companion rounded apastron in 1922, when the two components were separated by six seconds of arc. At present the separation is 5″.3, easy in small telescopes. The periastron approach will occur in 2007, and some readers of this column may then witness the drama that Smyth had watched. Meanwhile, any amateur can follow this pair from decade to decade, using the following position angles and separations, predicted from the orbit illustrated here:

1956.0	310°.0	5″.24
1960.0	308.3	5.08
1964.0	306.4	4.88
1968.0	304.3	4.67

WALTER SCOTT HOUSTON



This is the apparent orbit of Gamma Virginis, according to Dr. K. A. Strand. At periastron, the two 4th-magnitude components of this famous binary are only 0.3 second of arc apart. Dots are averages of visual observations of the companion's position; open circles represent some of the measurements from photographs. After the "Annalen" of the Leiden Observatory.

VARIABLE STAR MAXIMA

May 1, R Pegasi, 230110, 7.9; 8, S Carinae, 100661, 5.7; 11, S Herculis, 164715, 7.6; 12, T Herculis, 180531, 8.0; 13, R Serpentis, 154615, 6.8; 17, W Andromedae, 021143, 7.5; 27, V Monocerotis, 061702, 7.1; 30, V Ophiuchi, 162112, 7.5. June 1, V Bootis, 142539a, 7.9; 9, R Sagittarii, 191019, 7.2.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.

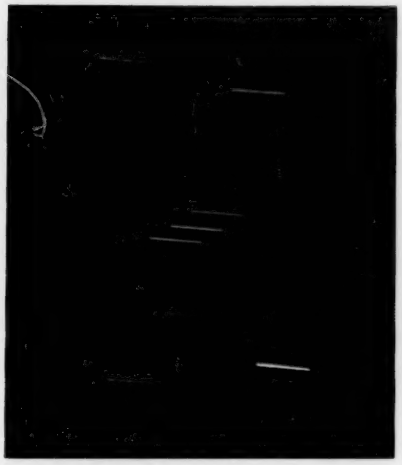
MINIMA OF ALGOL

May 2, 18:12; 5, 15:01; 8, 11:50; 11, 8:39; 14, 5:28; 17, 2:17; 19, 23:05; 22, 19:54; 25, 16:43; 28, 13:32; 31, 10:21. June 3, 7:10; 6, 3:59; 9, 0:48.

These minima predictions for Algol are based on the formula in the 1953 *International Supplement* of the Krakow Observatory. The times given are geocentric; they can be compared directly with observed times of least brightness.

PHOTOGRAPH OF ORION

This star-trail picture of Orion was taken by Vincent J. Steadman and me on February 25, 1955. We used a Kodak Pony 135 camera, mounted on a tripod



and opened for 15 minutes at f/4.5, at about 8 o'clock in the evening. The camera has a focal length of two inches. The film was Eastman Plus X, panchromatic, so Betelgeuse shows up well even though it is a red star. I am 14 years of age.

THOMAS COARD
3907 N. Rogers Ave.
Baltimore 7, Md.

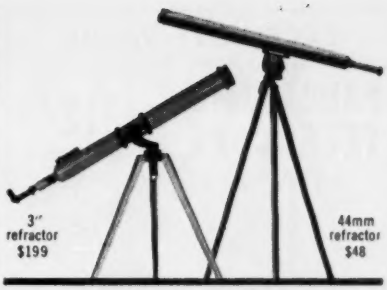
JUPITER II TRANSITS III

On the evening of February 19, 1955, nine members of the observing group of the Amateur Astronomers Association saw what was undoubtedly a very unusual phenomenon pertaining to satellites **II** and **III** of Jupiter.

Using a 6-inch reflector with a $\frac{3}{4}$-inch eyepiece and a Barlow lens (250x), we first examined the planet at 9:45 p.m. Eastern standard time. At that time, two satellites were seen to the east and one to the west of Jupiter. This did not strike us as being unusual, but when we looked again at 10:45, the satellite on the west was clearly resolved into two objects, separated by about four seconds of arc. We inferred that at our first observation either one moon had occulted the other or that they had approached to within a fraction of a second of arc. The next day we concluded that **II** passed in front of **III**, as both were moving eastward toward the planet.

Robert G. Brookes, Jupiter Recorder for the Association of Lunar and Planetary Observers, has received a report of this event from Elmer J. Reese, of Uniontown, Pa., who observed satellite **II** transit directly across the center of satellite **III** at 9:22 p.m. EST for mid-transit. Our first observation was made only 23 minutes later.

WILLIAM H. GLENN
523 E. 156th St.
New York 55, N. Y.



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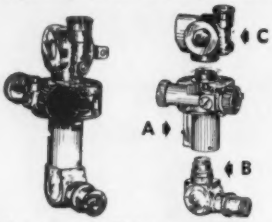

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SUNSPOT NUMBERS

February 1, 25, 19; **2**, 33, 28; **3**, 40, 32; 4, 35, 34; **5**, 28, 32; **6**, 31, 32; **7**, 36, 34; **8**, 27, 24; **9**, 26, 28; **10**, 30, 27; **11**, 29, 27; **12**, 28, 26; **13**, 15, 28; **14**, 13, 10; **15**, 11, 8; **16**, 11, 16; **17**, 1, 7; **18-20**, 0, 0; **21**, 12, 0; **22**, 19, 9; **23**, 27, 19; **24**, 27, 28; **25**, 29, 28; **26**, 31, 30; **27**, 33, 30; **28**, 36, 26. Means for February: 22.6 American; 20.8 Zurich.

Dr. M. Waldmeier, of Zurich Observatory, has predicted smoothed monthly sunspot numbers for the next few months: May, 18; June, 20; July, 22; August, 24.

The American and Zurich daily numbers are provisional, and are subject to later adjustment. Dr. Waldmeier has supplied the following definitive sunspot numbers for 1954: January, 0.2; February, 0.5; March, 10.9; April, 1.8; May, 0.8; June, 0.2; July, 4.8; August, 8.4; September, 1.5; October, 7.0; November, 9.2; December, 7.6. Yearly mean for 1954: 4.4.

Above are given the date, the American number, then the Zurich number. These are observed mean relative sunspot numbers, the American computed by D. W. Rosebrugh from AAVSO Solar Division observations, the Zurich numbers from Zurich Observatory and its stations in Locarno and Arosa.

MAY METEORS

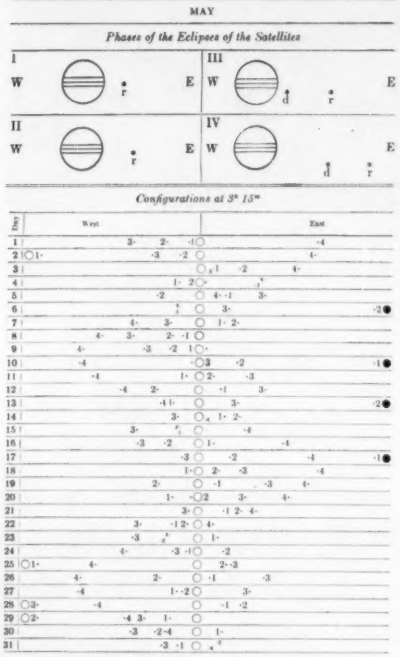
The Eta Aquarid meteor shower, associated with Halley's comet, occurs during the first 10 days of May, but the moon will seriously handicap observations this year. Maximum activity is on the 5th, when the hourly rate would reach 12 by dawn, if moonlight did not interfere. The swiftly moving shower meteors fan out from a radiant point at right ascension 22ʰ 24ᵐ, declination 0°.

E. O.

JUPITER'S SATELLITES

The configurations of Jupiter's four bright moons are shown below, as seen in an astronomical or inverting telescope, with north at the bottom and east at the right. In the upper part, *d* is the point of disappearance of the satellite in Jupiter's shadow; *r* is the point of reappearance.

In the lower section, the moons have the positions shown for the Universal time given. The motion of each satellite is from the dot toward the number designating it. Transits over Jupiter's disk are shown by open circles at the left, eclipses and occultations by black disks at the right. The chart is from the *American Ephemeris and Nautical Almanac*.



OCCULTATION PREDICTIONS

Data for the occultation of Eta Gemi norum f on May 23-24 appeared in the April issue, page 254.

PREDICTIONS OF BRIGHT MINOR PLANET POSITIONS

Herculina, 532, 9.1. May 3, 16:15.2 +1-23; 13, 16:07.1 +1-24; 23, 15:58.0 +1-04. June 2, 15:49.1 +0-22; 12, 15:41.5 −0-40; 22, 15:35.8 −1-59.

Pallas, 2, 9.0. May 23, 17:41.2 +24-23. June 2, 17:33.4 +25-15; 12, 17:24.9 +25-36; 22, 17:16.5 +25-26. July 2, 17:08.8 +24-46; 12, 17:02.6 +23-39.

Ceres, 1, 7.7. May 23, 19:52.3 −25-27. June 2, 19:50.9 −26-13; 12, 19:46.9 −27-06; 22, 19:40.4 −28-02. July 2, 19:32.1 −28-58; 12, 19:22.6 −29-49; 22, 19:13.1 −30-29. Aug. 1, 19:04.5 −30-59; 11, 18:57.8 −31-16.

After the asteroid's name are its number and the magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1950.0) for 0ʰ Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

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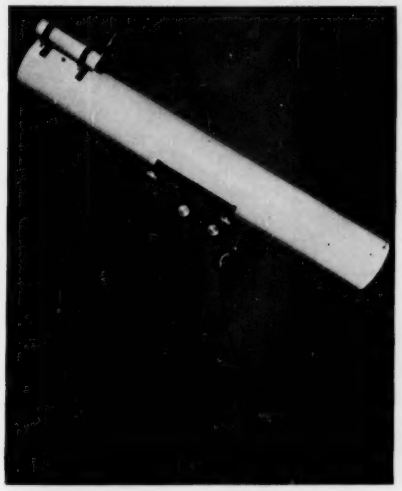

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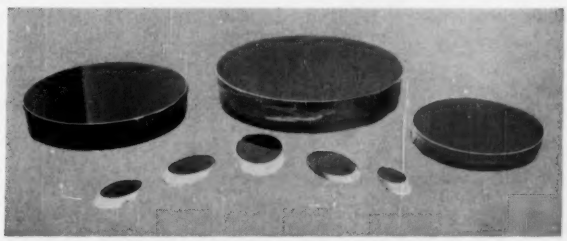

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Edwin C. Dimling, Flushing, N. Y.
Russell Mumaw, Harrisonburg, Va.
Steven S. Tigner, Plainville, N. Y.

and each will receive a UNIHEX as a prize.

All entrants have already been sent, as a gift, a copy of **The Nature of the Universe**, by Fred Hoyle. Our sincere thanks to everyone for the many interesting names and helpful suggestions.

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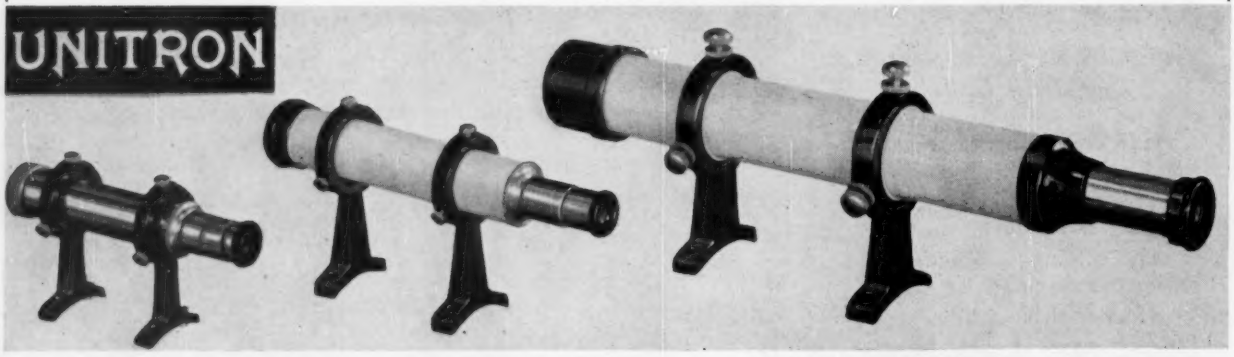

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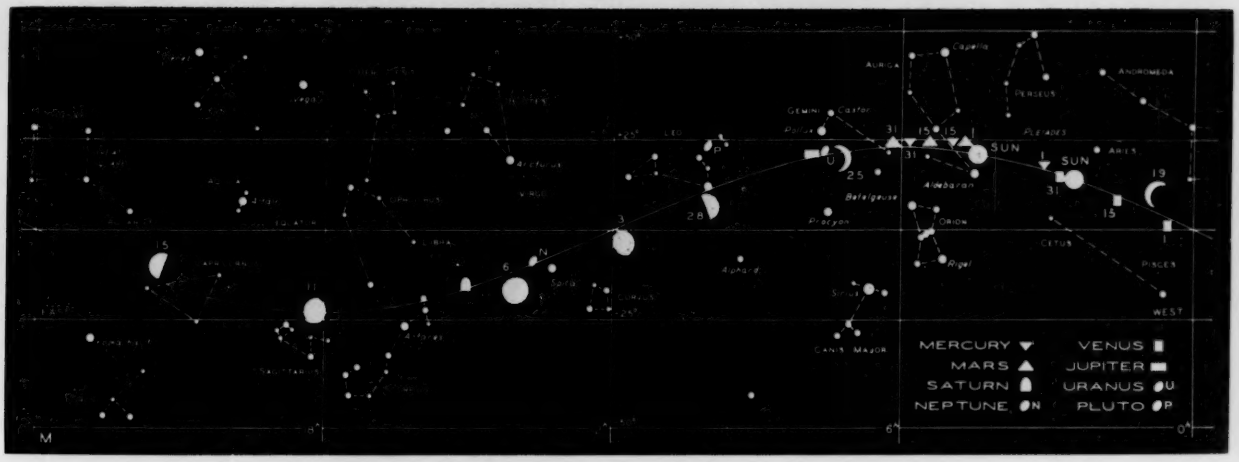

THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

Mercury is visible nearly all month in the evening sky. As early as the 3rd it sets one hour after the sun, and is of magnitude −1.2. Elongation occurs on the 21st, when Mercury sets two hours after sunset, although only 22° 25′ east of the sun. The planet is becoming steadily fainter, dimming to +1.4 by month's end, when it sets 1½ hours after the sun.

Venus is a −3.3-magnitude object rising an hour before the sun. Its nearly full disk is 12″ in diameter.

Mars is traveling across eastern Taurus, entering Gemini at the close of the month. It sets shortly after twilight ends. Mars is to the east of Mercury all month, but fainter, at 2nd magnitude.

Jupiter, moving eastward in Gemini, sets at midnight around May 8th. In mid-month it shines at magnitude −1.5, and in the telescope its disk is 34″.6 in equatorial diameter. See below for information about the May 10th conjunction with Uranus.

Saturn arrives at opposition with the sun on May 9th, at a distance of 828 million miles from Earth. Visible all night, this planet appears at magnitude +0.3 as it moves westward in Libra. Telescopically, the northern face of the ring system is seen, inclined 21°.3 to the line of sight. The longest diameter of the ring system is 42″, and the planet's disk is 17″ across.

Uranus is near Jupiter in eastern Gemini all month. An extremely close conjunction occurs on May 10th, when Jupiter passes one minute of arc south of 6th-magnitude Uranus. The changing configuration of the two planets during the week before and the week after will be a worthwhile sight in binoculars and small telescopes. It will be of interest to plot Jupiter, its moons, and Uranus during this period. For further details of this conjunction, see page 251 of the April issue.

Neptune continues in retrograde motion in eastern Virgo, and may be viewed most of the night. On the 19th this 8th-magnitude planet passes about 4′ north of 5.2-magnitude 82 Virginis. E. O.

MOON PHASES AND DISTANCE

Full moon	May 6, 22:14		
Last quarter	May 15, 01:42		
New moon	May 21, 20:58		
First quarter	May 28, 14:01		
Full moon	June 5, 14:08		
	May	**Distance**	**Diameter**
Apogee	9, 00h	252,300 mi.	29′ 26″
Perigee	22, 04h	222,100 mi.	33′ 26″
	June		
Apogee	5, 03h	252,400 mi.	29′ 25″

UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown.

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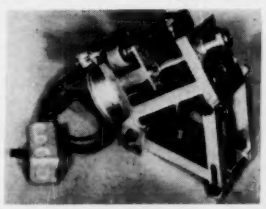

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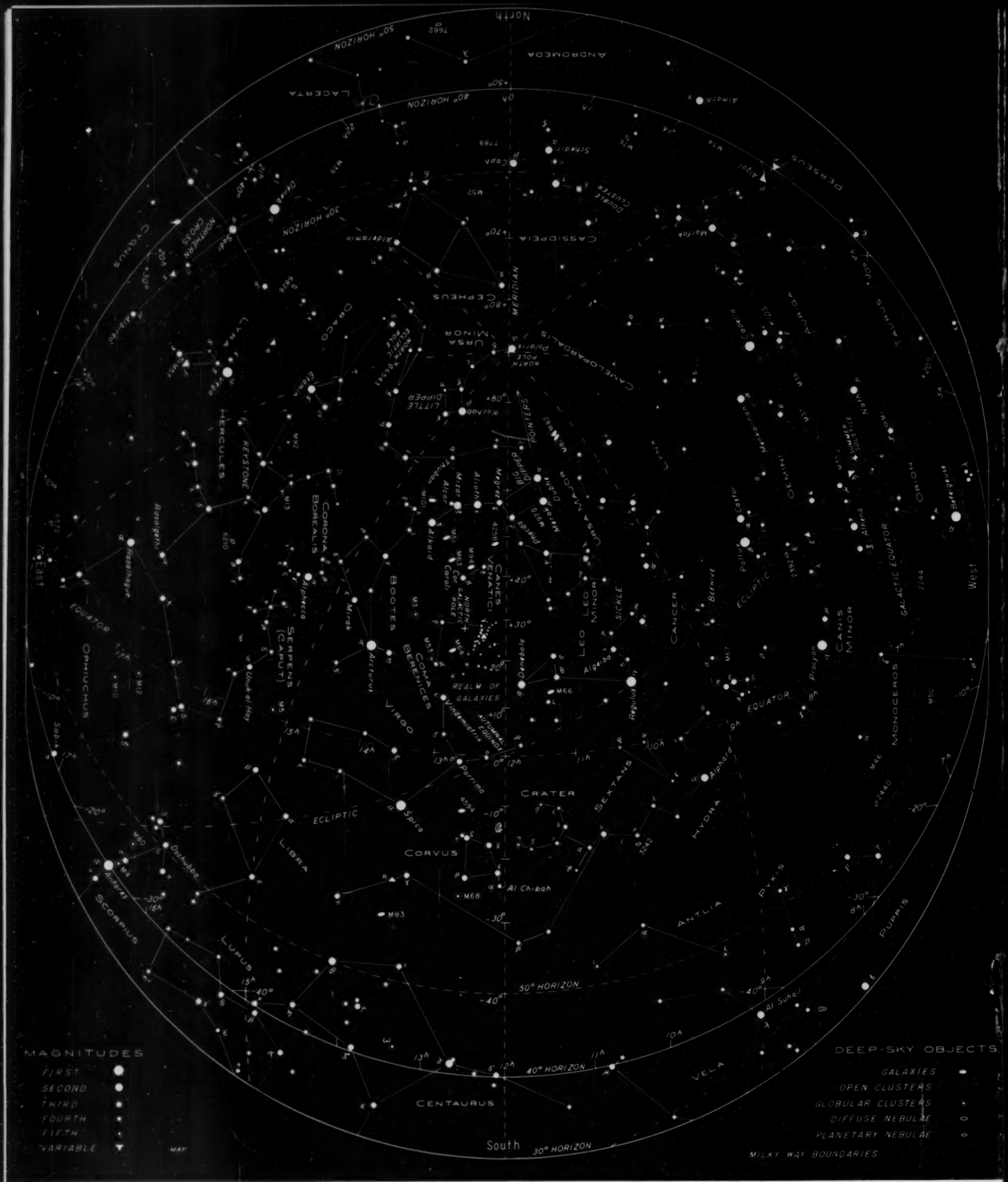

STARS FOR MAY

The sky, as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of May, respectively; also, at 7 p.m. on June 7th. For other dates, add or subtract ½ hour per week.

Now nearly overhead, the seven bright stars of Ursa Major are easy for the beginner to find. Corona Borealis, the Northern Crown, is a fine compact group well up in the east. This is a good time to locate the quadrilateral of Corvus, the Crow, low in the south.

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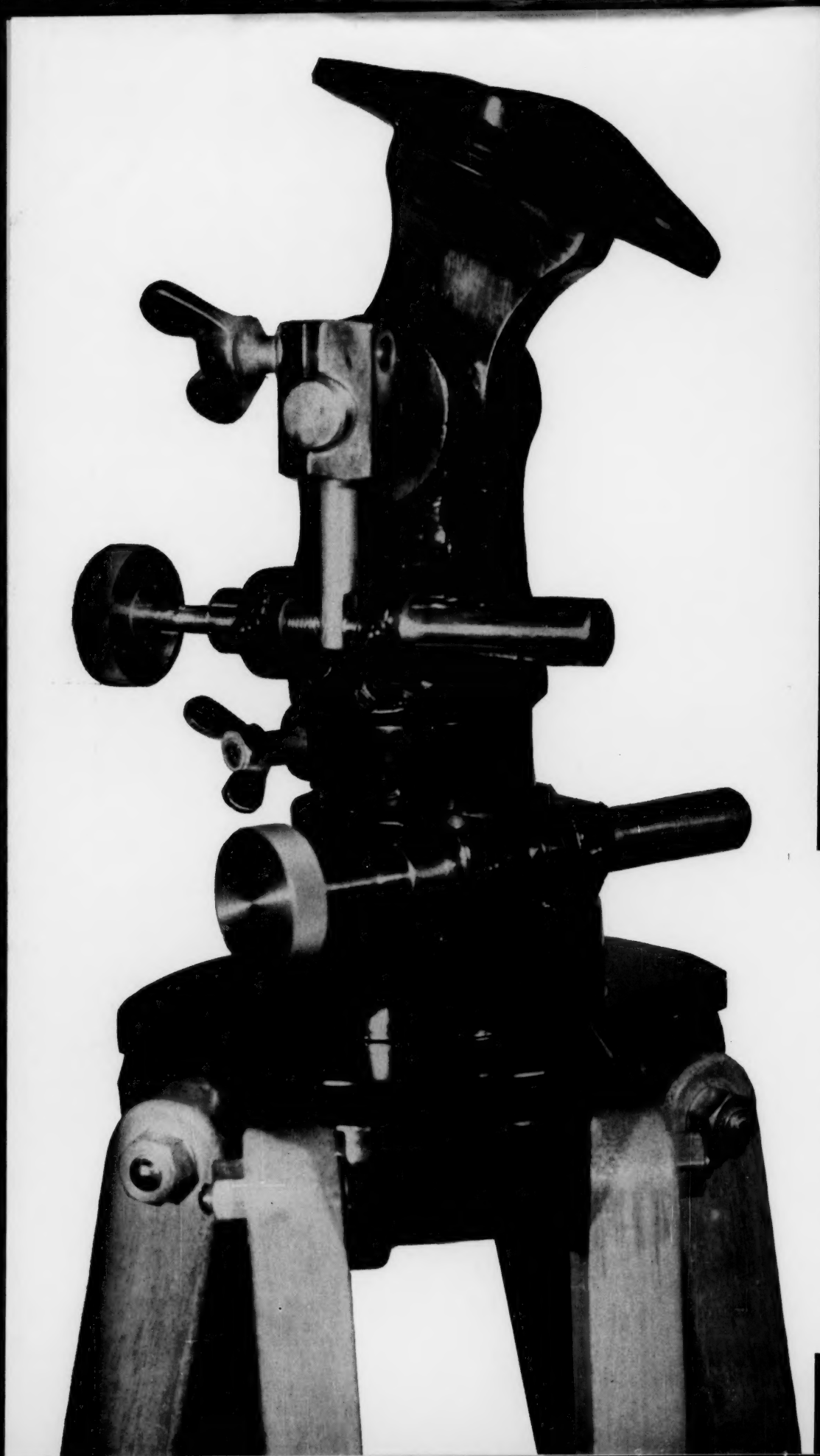

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